Instruments

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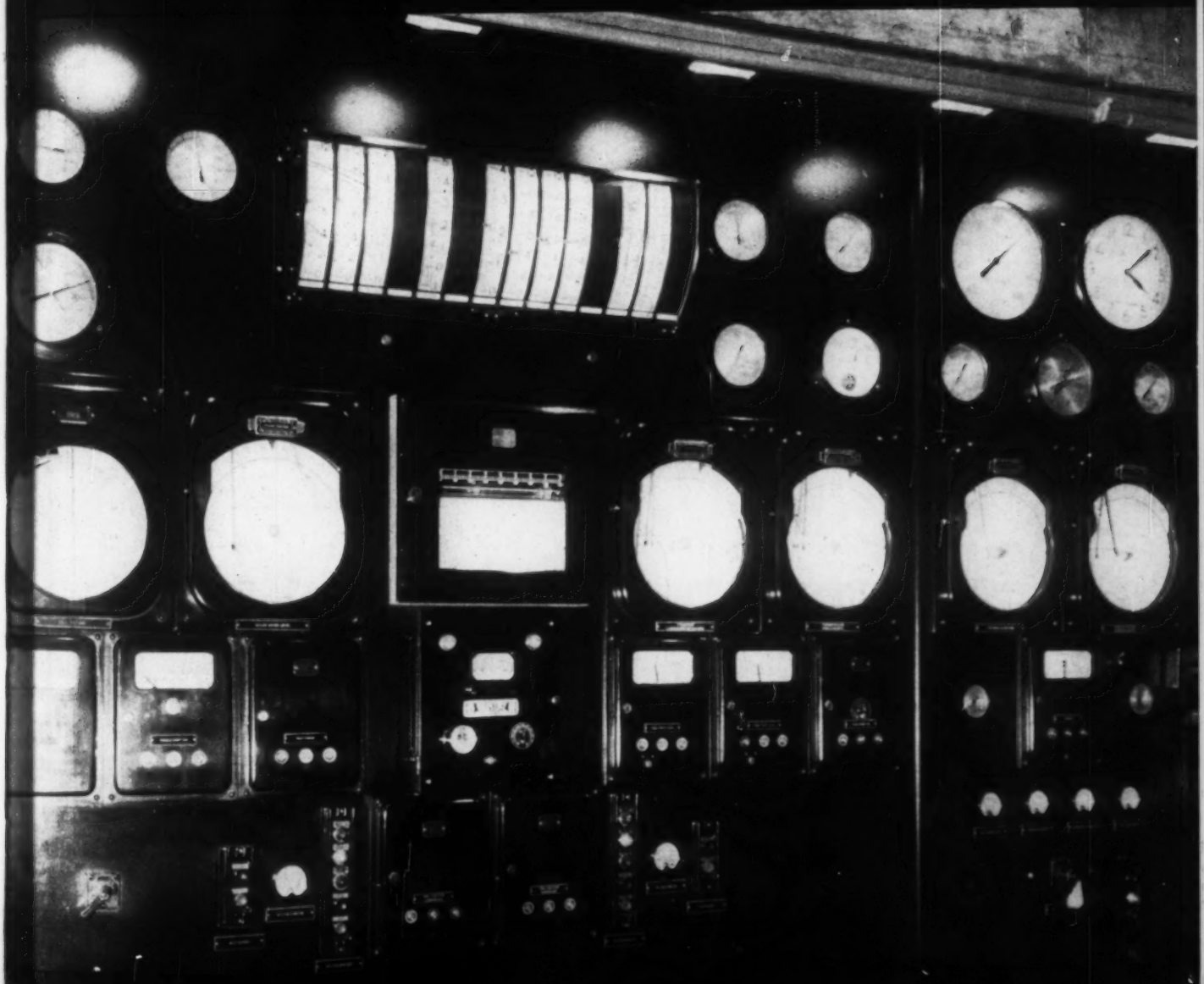

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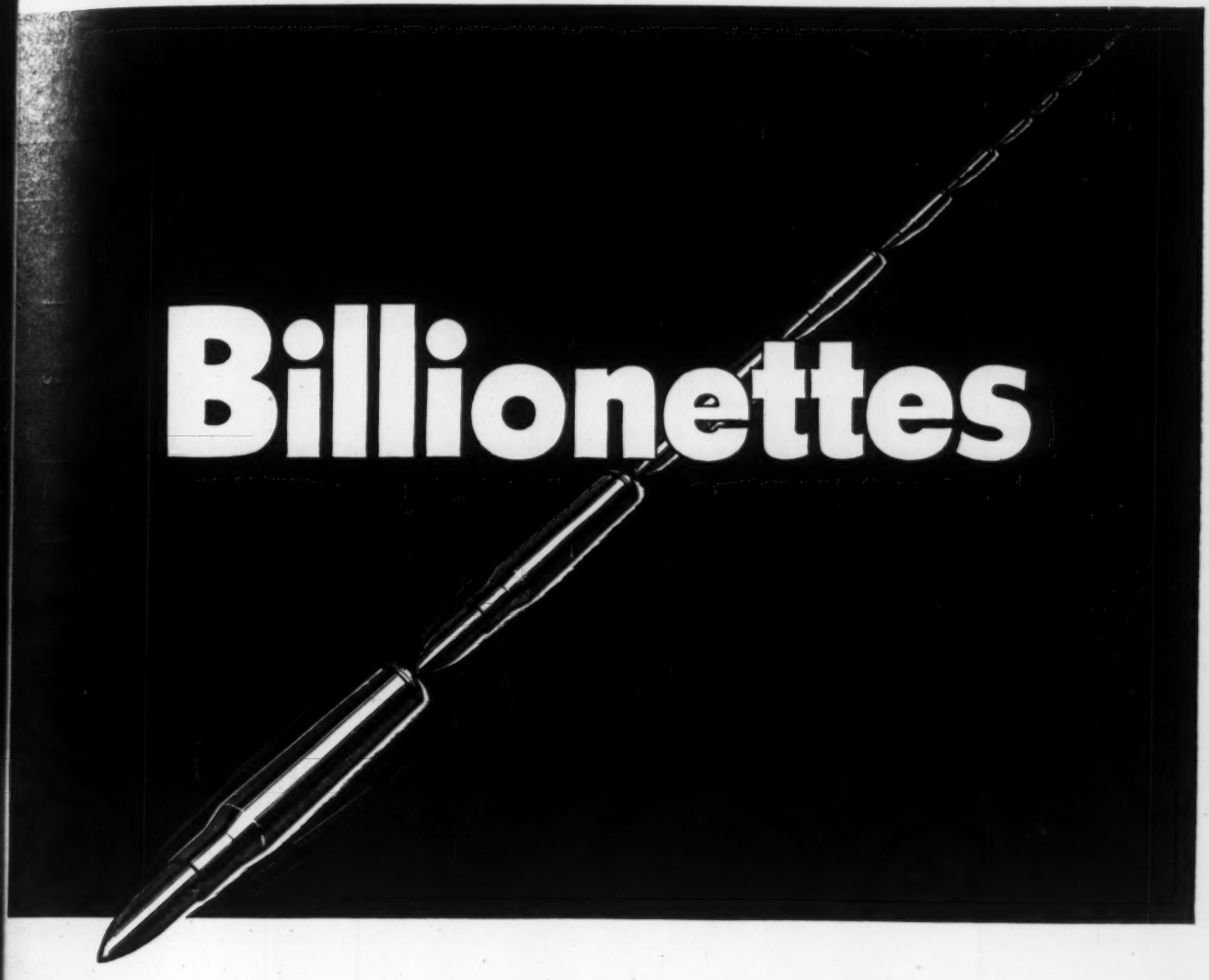

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Instruments

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Courtesy The Cochrane Corp.

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Modernized Testing—II

BY modernized testing we mean more than soundproof rooms with observation windows, even more than remote-control systems: we mean

the measurement of every factor influencing the performance of the product tested;

the accurate measurement of even minor factors;

the continuous measurement of every factor;

the autographic recording of many data previously logged by hand; and

the positive control of every known-and-controllable condition

—not only when testing components on the ground but when testing assembled ships in flight."

SUCH were the opening words of a Progress Report* we made exactly three years ago. This report dealt mostly with the testing of engines and carburetors. We congratulated a number of companies and government agencies but we made it plain that there was room for further improvement. We were not satisfied with the overall picture three years ago and we are not satisfied today. However, precisely because of our impatience with the slowness of the general advance, we are especially delighted with *specific* advances and we have always been doing everything in our power to obtain complete descriptions of the improved methods from the most authoritative sources. Since 1940 we have published a number of such descriptions—not all in one issue under one title, but scattered. Up to now, the most significant appeared in our two Special Aviation Issues (Oct. 1941 and April 1942). We can promise several more; as a matter of fact we have some manuscripts on our desk but they are much too brief and somewhat too commercial; therefore, efforts are being made to obtain permission to publish complete non-commercial descriptions in *Instruments*.

A satisfactorily complete technical and non-commercial description of the new adjustable orifices, written exclusively for *Instruments*, appears below. Although it is adequately complete as a description, it is not the whole story, because the whole story would include a description and discussion of the methods previously recognized as "official" or "standard." Even more fascinating, from the human-interest point of view, would be the success story—the narration of a new method's struggle for recognition and its final triumph. This particular story may not be told in full at this time but here are its highlights:

In approving or disapproving various methods of testing aircraft, aircraft engines, aircraft instruments and many accessories, Army and Navy Air Force officers have a tremendous responsibility. They realize that their decisions must safeguard the precious lives of the flower of American youth—those young men of superior physique, mentality and character who have been chosen as members of bomber crews and as combat pilots of single-seater fighters. Conscious of this heavy responsibility, these technical officers cannot take chances. It is their duty to insist not only that the testing instruments be of the highest possible grade but that the fundamental *methods* of testing be backed by the full authority of the National Bureau of Standards, of the great engineering societies, etc. In the particular case of measuring air flow, the Fluid Meter Research Committee of the ASME, the American Gas Association, the National Bureau of Standards and all other official bodies concerned were unanimous (and still are unanimous in print) in specifying that the primary element be a certain form of thin-plate orifice or flow nozzle or Venturi tube—these three types of elements having been standardized after several decades of thorough investigations.

Study of all reports led to the conclusion that the preferred installation should consist of a set of standard nozzles, together with certain other parts, constituting what became known as the standard Air Bottle System. An obvious disadvantage of this method is that in order to make tests over a wide range of flow rates it is necessary to interchange the nozzles manually in going from the warming-up speed to the take-off speed and *vice versa* in the course of each test on each engine or carburetor. Not only does it take time and labor to change these nozzles but there is always the possibility of leaks around these nozzles (which sometimes made some test dubious and required repetition of the tests). Moreover, use of this method was limited to normal atmospheric pressure and temperature conditions; for altitude tests, extensive modifications were necessary.

The loss of time was considerable because it always required several minutes to remove one nozzle, substitute another and make sure that everything was right. Nobody realized this more keenly than did the Army and Navy officers themselves. They knew that the lives of many of our boys could be lost by "too little and too late." Their desire for a quicker method was as strong as the yearning of all civilian engineers interested in this branch of aircraft production. Therefore, when

Smaller margins starting next issue. Details on page 62.

Cash for your ideas on aiding America's war effort through instruments. See "Shop Kinks" offer on page 93. Also, the broad "Speeding Up War Work" invitation (December, pages 513 and 517) still stands.

*"Aircraft Manufacturers Modernize Testing Facilities," by M. F. Behar, *Instruments*, Feb. 1940, pages 50-51.

they heard of the adjustable-orifice method, they insisted only that the method prove its accuracy and reliability beyond doubt. That was their duty.

Right here we want to lay stress on the important distinction between the intrinsic accuracy of a single device and what for want of a better term may be called its "reliability" when this device constitutes one element in a measuring system. Consider the adjustable orifice by itself and you will conclude that *it* is an accurate device. The basic manually-operated adjustable orifice shown in Figs. 1 and 2 of Mr. Green's article is of simple design and its component parts are machined to unusually close tolerances. For example, the lead error of the 10-pitch thread which is cut into the stainless-steel stem, the irregularities in the nut and bearings, the engraving errors in the 100-division hand-wheel scale, etc., all add up to such a small total error that the assembly can be compared to a machinist's micrometer. Thus the *intrinsic* accuracy of an adjustable orifice is higher than that of most other measuring devices associated with it in any testing-department installation: thermometers, hygrometers, barometers, dynamometers, fuel-weighing devices, etc.

Why then was the adjustable orifice not considered "official" or "standard" and why was it not accepted by the Army until so recently? The reason—and this reason plays an important part in all branches of measurement—is that the orifice is only the primary element of a measuring system. For each size of the "official" fixed concentric orifice, years of arduous labors had been required to determine the proper distances of upstream and downstream pressure taps, the proper slope of pressure piping, the proper design and construction of seals and traps and a multitude of other installation details. Without this accumulated knowledge, even an 18-carat gold orifice, dimensionally accurate to a microinch, would not and could not have been officially certified as accurate in actual use for flow measurement: the entire system and hence the method could not enjoy the reputation for reliability which it has enjoyed since the nineteen-twenties. In order to have the adjustable orifice similarly accepted, engineers and research men in the meter industry, in engineering schools and elsewhere had to "lick the installation problems" of the adjustable-orifice method and determine exactly the effects of various factors. They succeeded in doing in short order what had taken several decades for the standard orifices, nozzles and Venturis. The last chapter occurred a year ago: it began when none other than *the Air Force officers themselves* suggested that tests be conducted to compare the accuracy and dependability of the faster adjustable-orifice method with the slower but already approved Air Bottle System.

The happy ending is doubly happy because not only has the adjustable orifice won success like a Horatio Alger hero, but because this story should inspire a similar happy ending in many other fields of testing—wherever there is room for improvement!

And there's lots of room for improvement—for *modernization*, for *automatization*—in nearly every department where repetitive inspections and tests are being made. Not in *yours*? Come, come, suppose you read our platform once more.

> "By modernized testing we mean more than sound-proof rooms with observation windows, even more than remote-control systems: we mean
> the measurement of *every* factor influencing the performance of the product tested;
> the *accurate* measurement of even minor factors;
> the *continuous* measurement of every factor;
> the *autographic* recording of many data previously logged by hand; and
> the positive control of *every known-and-controllable* condition.

—not only when testing aviation products but when testing *your* products. —M. F. BEHAR

Speeding Up Measurements of Air Flow to Aircraft Engines and Carburetors

By J. P. GREEN
Mechanical Engineer, Bailey Meter Co., Cleveland, Ohio

MORE than ten years ago the adjustable orifice was developed for test work as well as for commercial metering; but not until the early part of 1942 did it win from aircraft industry engineers and Air Force technical officers their full recognition that this device can save time and simplify procedures in important tests and can also give readings as trustworthy as those of the established standards. One factor contributing to this recognition has been the relatively recent development of special designs with added features. With the permission of all parties concerned, these recent refinements, and some of the results, are hereby disclosed for the first time.

There are now four distinct designs or models of adjustable orifices. These include three types of manually-operated units and the remote-positioned air-operated adjustable orifice.

APPLICATIONS

Adjustable orifices are suitable for making flow measurements over an extraordinarily wide range. By proper selection of size they will accurately measure the flow over a range of more than 150 to 1, employing a single manometer or flowmeter, without at any time going below 50% of scale on a flow basis. As such, they are not only suitable for production tests of aircraft engines or carburetors but are likewise suitable for experimental tests where an exceptionally wide flow range is necessary. They can be operated under all conditions of temperature and pressure and for this reason can be used to advantage when conditions simulating altitude are desired, or where tests are to be made under exceptionally low or high temperatures.

Moreover, it is entirely practical to compensate for variations in temperature and pressure in the

actual orifice setting so that the manometer employed can be read directly. This is accomplished by applying temperature and pressure correction factors to the flow-differential curve of the particular orifice being employed. Whenever corrections for variations in temperature and pressure are to be made in this manner, a manually-operated adjustable orifice should be employed, since it would be impractical to make such readjustments when using an air-operated unit.

In the aircraft engine testing field, most applications thus far have been for engine test cell installations and for the measurement of air to aircraft carburetor test cells. However, the use of an adjustable orifice is by no means limited to the measurement of the flow of air: a number of units are being employed for steam and water flow measurement where a wide range is necessary. Units are available in sizes ranging from 2½" to 48".

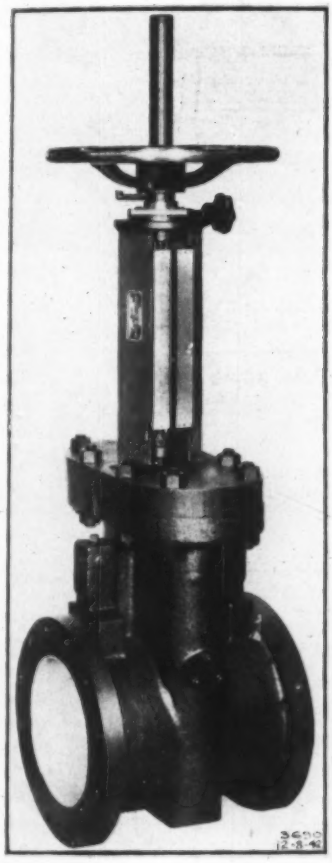


Fig. 1. Bailey Meter Co.'s manually-operated adjustable orifice.

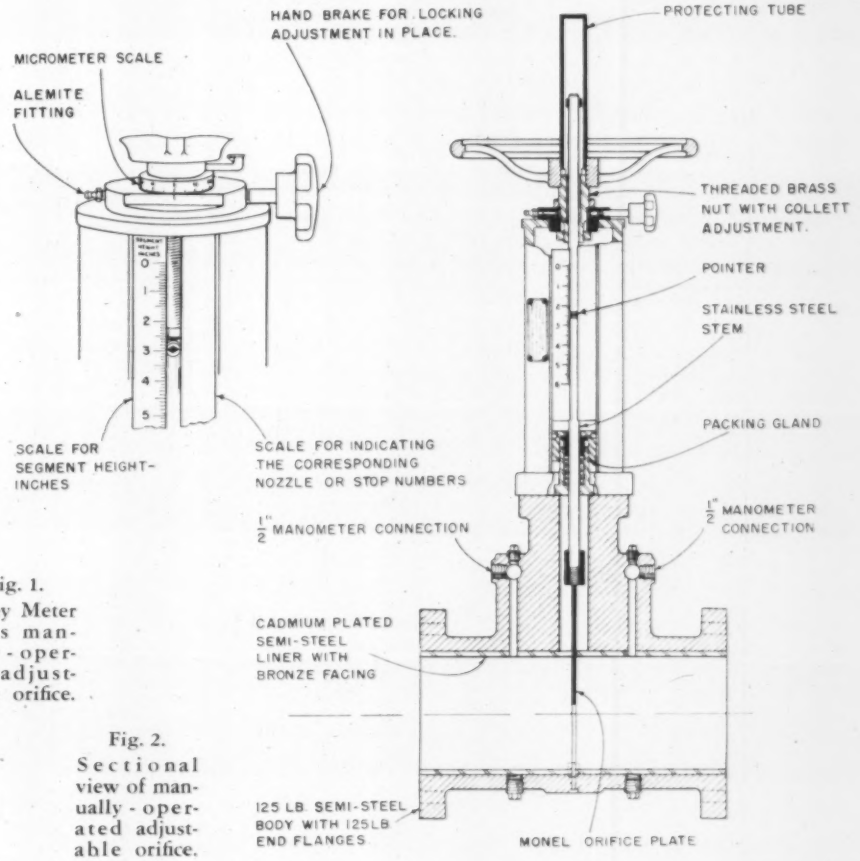

HAND BRAKE FOR LOCKING ADJUSTMENT IN PLACE.
PROTECTING TUBE
MICROMETER SCALE
ALEMITE FITTING
THREADED BRASS NUT WITH COLLETT ADJUSTMENT.
POINTER
STAINLESS STEEL STEM
PACKING GLAND
SCALE FOR SEGMENT HEIGHT-INCHES
SCALE FOR INDICATING THE CORRESPONDING NOZZLE OR STOP NUMBERS
½" MANOMETER CONNECTION
½" MANOMETER CONNECTION
CADMIUM PLATED SEMI-STEEL LINER WITH BRONZE FACING
125 LB. SEMI-STEEL BODY WITH 125 LB. END FLANGES
MONEL ORIFICE PLATE

Fig. 2. Sectional view of manually-operated adjustable orifice.

It is noteworthy that more than 150 adjustable orifices of all types, in sizes ranging from 6" to 28" are either in active service or are being supplied to the various aircraft engine and carburetor manufacturers and laboratories, including nine of the major manufacturers of aircraft engines and carburetors and the leading Aircraft Engine Experimental Laboratories in the United States and Canada.

Characteristics Related to Test Work

In addition to accuracy, exceptional flexibility of adjustment, speed of operation and adaptability to any type of fluid flow measuring installation, the exceptional sturdiness of construction and simplicity of operation of the adjustable orifice insures continuity of service. The segmental type orifice plate employed is always completely protected from possible damage. The operating thread in manually-operated units, or the stop system and operating piston in the air-operated unit, are fully protected against injury. In all designs, means are provided for taking up a small amount of wear which occur after long periods of operation.

Manually-operated Types

The basic manually-adjustable orifice consists essentially of a movable segment-form orifice plate carried by an accurately machined operating stem positioned by means of a handwheel. A micrometer scale associated with the handwheel permits reading the orifice plate position to 0.001" and is used for final setting. For preliminary setting, two clearly-visible indicating scales are provided, one of them engraved in inches and tenths. The orifice body is made of semi-steel, except when it is to operate at sub-zero temperatures, in which case 3½% nickel is added to the casting. The liners are of cadmium-plated semi-steel with bronze facings at either side of the orifice plate, which is Monel metal. Other features include an accessible hand brake for clamping the orifice at any predetermined position, suitable means for lubricating the orifice stem, and a protecting tube for protecting the orifice stem when it extends above the handwheel. Figs. 1 and 2 show the most recent model of this basic type.

For some applications, the orifice is positioned by the linear scales in accordance with a capacity-

vs.-orifice-setting curve which is supplied with each unit. For production tests of engines and carburetors, it sometimes is desirable to mark the second indicating scale in terms of equivalent air bottle orifice settings or other predetermined settings which are to be used in the course of the scheduled tests. This auxiliary scale permits the operator to change adjustments at a glance without further reference, increasing the speed of operation.

The standard manually-operated adjustable orifice may be installed in a horizontal, vertical, or inclined pipe line, with the stem extending at right angles to the line. It is preferable to have the stem extend at or above the horizontal to reduce the quantity of moisture which is carried down the connecting pipe lines to the manometer.

On some installations where the pipe line in which the orifice is installed runs below the floor or above the ceiling of the operating room, or is located within the test cell, it would be inconvenient for the operator to position a standard adjustable orifice. In cases where it is possible to bring the orifice handwheel to a satisfactory elevation by simply extending the stem a distance of approximately two feet, the *extension stem type* of manually-operated adjustable orifice can be employed. Where a greater extension than about 24″ is necessary, the *remote manually-operated* adjustable orifice employing a floor stand operator, as shown in Fig. 3, may be employed. This design has been used for installations where the orifice is installed below the floor, on the floor above, or in a room adjacent to the control chamber.

The handwheel unit is an independent element whose sole function is to transmit its rotation to the handwheel or operating nut on the standard orifice. It is securely fastened to the floor, wall or ceiling of the operating room, with the handwheel located for convenient operation. It includes the same type of indicating scale, calibrated with the same precision as the standard scale of a manually-operated unit, permitting remote accurate reading and setting of orifice position.

The orifice body being some distance away from the operating stand, expansion and contraction of the piping and building structure will cause slight variations in the relative horizontal or vertical positions of the orifice and of the stand. Therefore, these two units are connected by a universal-joint linkage system. Proper agreement between orifice position and operator indication is assured, however, because the orifice is positioned solely by the rotation of the operating unit, and is not affected by relative horizontal or vertical position changes.

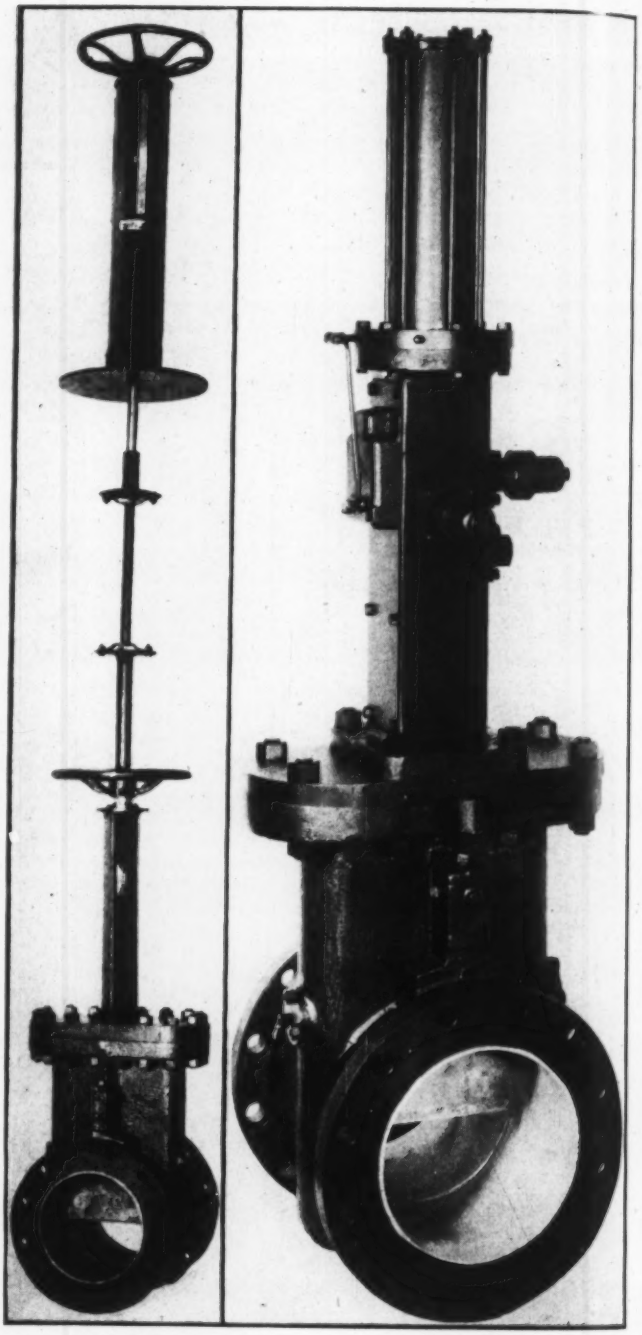


Fig. 3 (left). Bailey Meter Co.'s remote manually-operated adjustable orifice.

Fig. 4 (right). Bailey Meter Co.'s remote-positioned air-operated adjustable orifice.

Air-operated Adjustable Orifices

In some installations it is impractical to use any of the manually-operated types of orifices, or it is desirable to employ an extremely rapid means of changing orifice position according to a preselected series of orifice settings (which, in some instances, correspond to air bottle orifice capacities). For these applications, the *remote-positioned air-operated* adjustable orifice shown in Figs. 4 and 5 has been employed to advantage. It differs from the manually-operated unit in that a positioning cylinder with a series of stops in the orifice superstructure is employed instead of the handwheel arrangement. The air-operated stops are extended and retracted, and the orifice position altered, by means of position selector and operating valves remotely located on the operator's control panel. Any number of preselected positions up to ten is available on most standard units. The stops, individually adjustable for making minor changes, are set for a predetermined group of orifice settings, which may correspond either to air bottle orifice sizes or to a preselected series of areas utilizing the most accurate zone of the manometer or flowmeter scale over the entire operating range of the system.

The function of the operating valve is to apply air pressure to either side of the positioning cylinder piston to move the orifice plate in the desired direction. Each position selector valve is arranged

pply air pressure to the particular air-operated p indicated on the selector dial. This extends the p ager on that stop, which accurately determines t orifice position by contacting a shoulder on the o fice positioning stem at that point, preventing f ther travel of the orifice segment as it is being closed by the operating cylinder. When the position selector is set to the minimum setting point (position 2 in the case of the six-position selector valve shown in Fig. 5), all air-operated stops are retracted and the motion of the orifice is not stopped until the shoulder on the operating stem is intercepted by the minimum setting stop.

viously except that further interlocking is provided to prevent rotation of either position selector except when the orifice plate is fully retracted and the other position selector valve is in its "off" position.

The interlock system insures proper correspondence between the position indicated by the position selector valve in service and that of the orifice, and prevents improper orifice operation by requiring the following simple operating sequence:

1. Turn the operating valve to its "reset" position;
2. Turn the position selector clockwise to the new orifice position desired;
3. Return the operating valve to its "operating" position.

A complete change from any position to any other can be made in ten seconds or less.

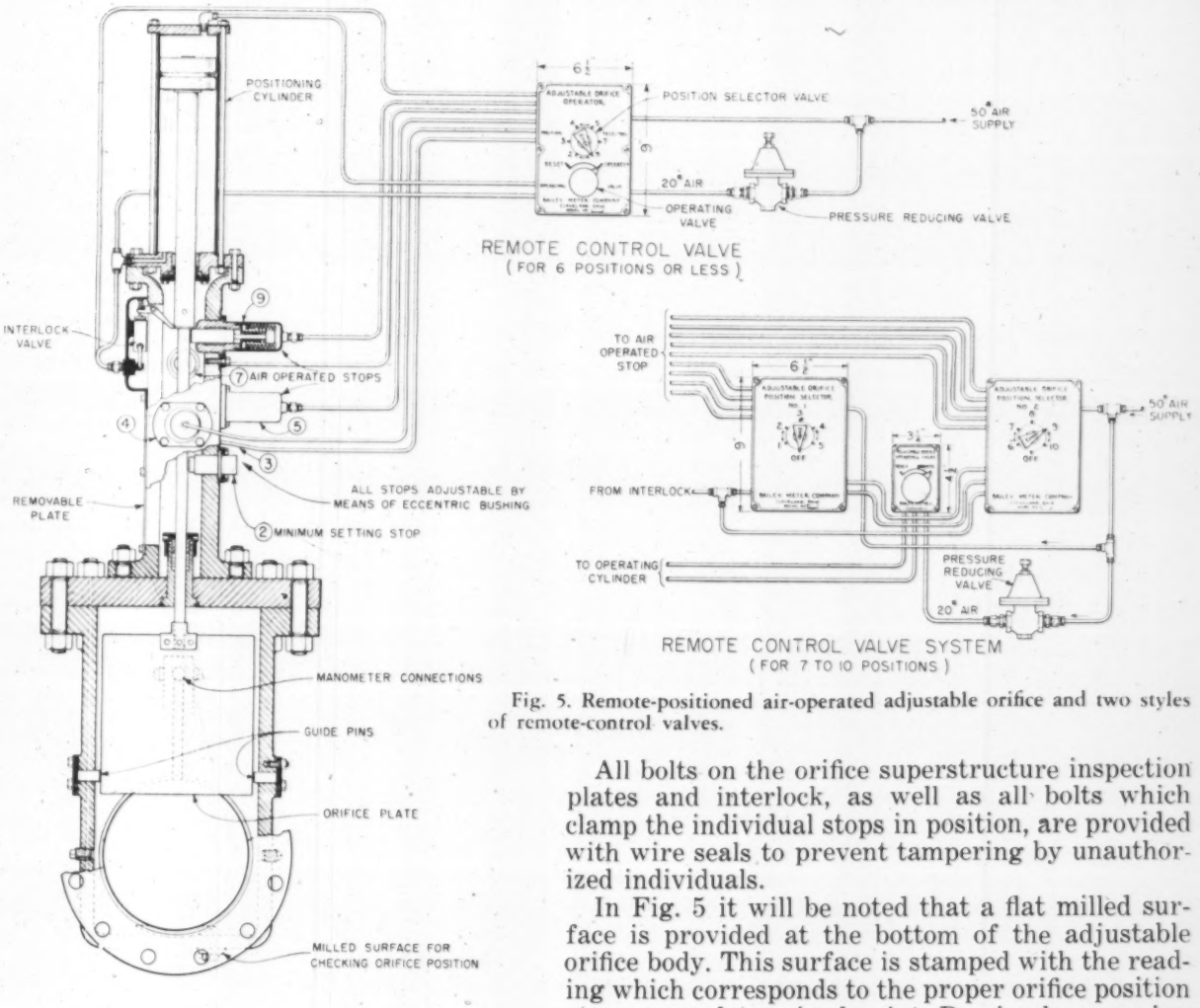


Fig. 5. Remote-positioned air-operated adjustable orifice and two styles of remote-control valves.

In order to insure fool-proof operation, a special interlock valve is installed on the orifice superstructure and a bellows-operated interlock is provided on each position selector. This interlock system is so constructed that it is impossible to change the setting on the position selector unless the orifice is fully retracted, at which point the interlock valve opens and applies pressure to the operating bellows on the position selector, permitting repositioning.

When six positions or fewer are desired, a combination position selector and operating valve is available, and the system functions as heretofore described. However, when seven to ten positions are required, two position selectors and a separate operating valve are necessary. The functions of these control valves are the same as described pre-

All bolts on the orifice superstructure inspection plates and interlock, as well as all bolts which clamp the individual stops in position, are provided with wire seals to prevent tampering by unauthorized individuals.

In Fig. 5 it will be noted that a flat milled surface is provided at the bottom of the adjustable orifice body. This surface is stamped with the reading which corresponds to the proper orifice position at some predetermined point. By simply removing the plug and inserting a depth gage, it is always possible to check the agreement between actual orifice position and the scale reading or stop setting. (This position-checking surface is provided on all adjustable orifice bodies now made, including the basic type.)

Installation

To obtain accuracy with any type of primary flow-measuring device, reasonable care must be exercised in the installation. It always is important to prevent turbulent flow at the inlet to the primary device; in the case of an adjustable orifice this must be accomplished by providing adequate straight pipe ahead of the orifice installation.

The majority of installations may be divided into two types: one with the adjustable orifice installed

in a *closed piping system*, with an air-conditioning system, blower, or some type of fitting ahead of the adjustable orifice as shown in the solid lines in Fig. 6; and the other with an *atmospheric intake* as shown by the dotted lines.

In the closed system, to insure accuracy, from 25 to 35 diameters of straight pipe must be provided ahead of the orifice, unless a straightening vane is installed. However, by the installation of a straightening vane located as shown in the figure, accurate results can be obtained with a total of 14 to 16 diameters of straight pipe, including the vane section. The length of straight pipe necessary when no straightening vane is employed is dependent upon the nature of the fittings and type of equipment in the pipe line ahead of that section.*

When the adjustable orifice is to be installed with an atmospheric intake, the required length of straight pipe on the inlet side is considerably reduced. It is recommended that a standard bell mouth be always employed at the intake end, and that the piping be arranged so that the bell mouth will not be located at a place where the air flow will be seriously influenced by openings such as windows or doors, ventilators, fan inlets or similar disturbances. By observing this precaution, it has been found that from 10 to 12 diameters of straight pipe at the inlet side of the orifice will insure satisfactory accuracy.

If pressure loss is of importance in connection with the installation, or if some type of flow control device, such as a butterfly valve, is to be installed following the adjustable orifice, it is important to provide at least four diameters of straight pipe between the discharge end of the orifice and the next fitting. This length is essential to permit maximum pressure restoration and, in the case of a control valve, to avoid any possibility of a reaction at the orifice from the throttling device. Where no such control device is installed and where pressure loss is not of great importance, however, from one to two diameters of straight pipe are considered sufficient on the downstream side of the adjustable orifice.

When considering piping requirements in general, circumstances often alter cases and it is always advisable to consult with the manufacturer before selecting the final piping arrangement.

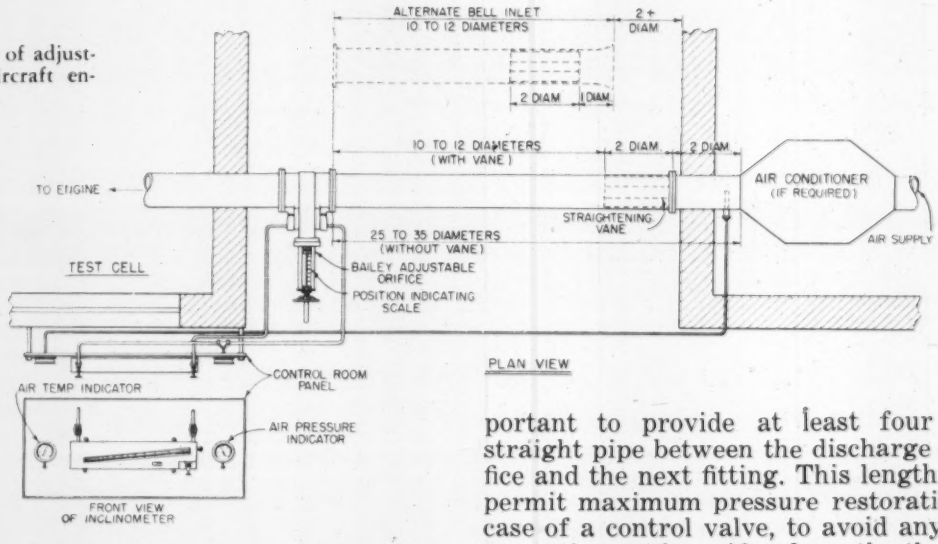


Fig. 6. Installation of adjustable orifice for aircraft engine tests.

Secondary Devices

The adjustable orifice can be used with any type of secondary device desired, such as a U-tube, inclined-tube manometer, or an indicating, recording and/or integrating flowmeter. For most aircraft engine testing installations an inclined-tube manometer of the type shown in Fig. 7 has been employed since it possesses numerous advantages over a simple manometer. *(Continued on page 103)*

*Editor's Note—See: "Selection and Installation of Flow Meters" by Raymond E. Sprenkle, *Instruments*, Vol. 15, March 1942, pages 75-82.—M. F. Behar.

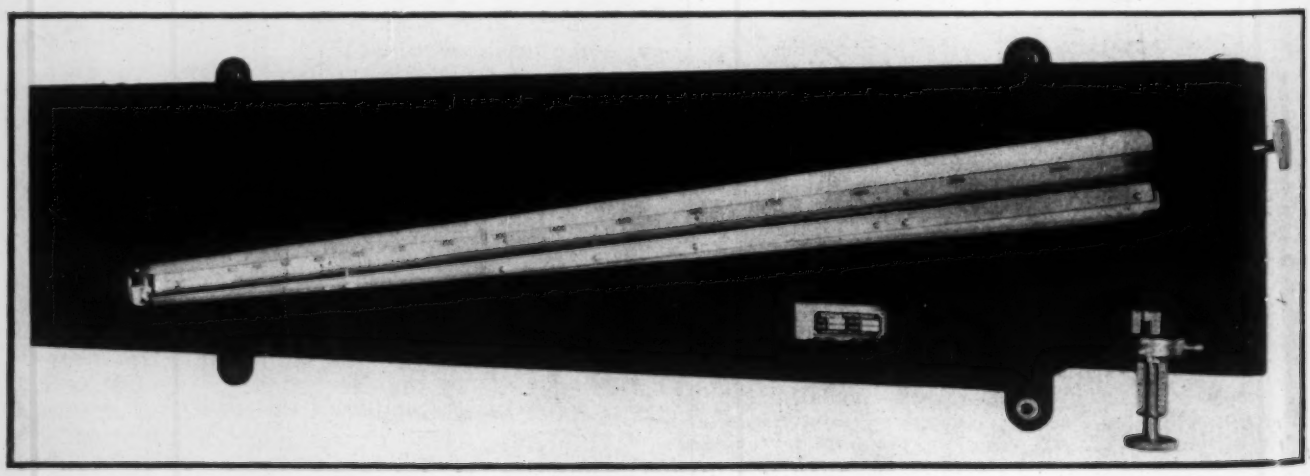
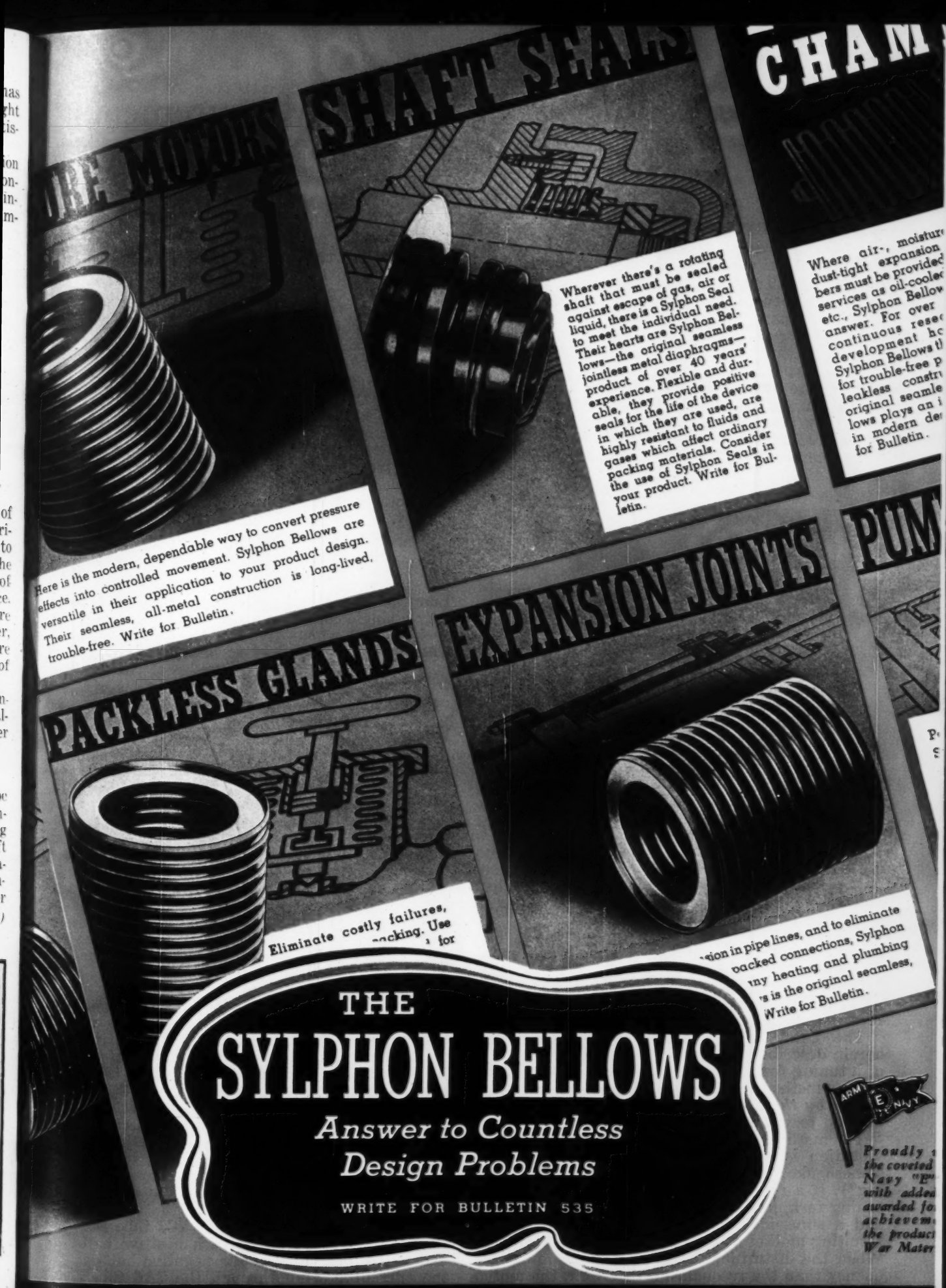


Fig. 7. The Meriam Co.'s adjustable-angle inclined-tube manometer.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A New Method of Frequency Measurement

By H. L. CLARK and J. E. HANCOCK
General Engineering Laboratory, General Electric Co., Schenectady, N. Y.

BASIC PRINCIPLE

FREQUENCY METERS, particularly for the measurement of frequency in a power system, in general depend on the resonance of an electrical circuit. These instruments are fully described in the standard reference works. Whether using one or two resonant circuits, all make use of the fact that the current through a tuned electrical circuit changes with the applied frequency. Various mechanical assemblies are used to move a pointer in response to this changing current to obtain an indication of the applied frequency. The sensitive frequency meter of this type regularly available has a scale range of 59½ to 60½ cycles per second.

Another type of frequency meter makes use of a bank of tuned reeds excited by the frequency to be tested. The reed whose frequency is nearest to the system frequency will show the greatest motion as an indication of the line frequency. These instruments are simple and rugged but do not lend themselves to accurate measurement of quite small frequency deviations.

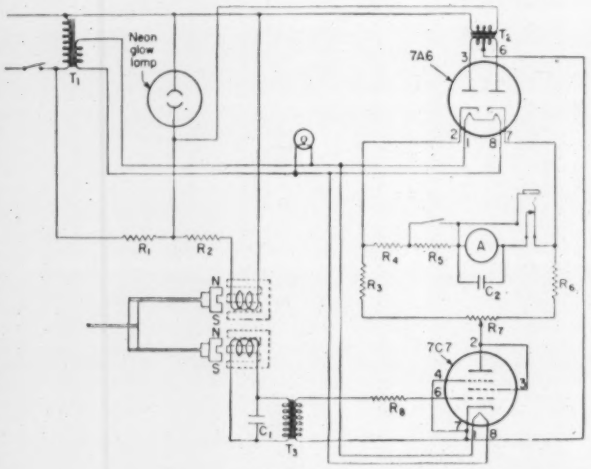

Fig. 1

The free vibration of a tuning fork has long been recognized as a frequency standard in measurements of musical pitch. Tuning forks, each driven at its natural frequency, are employed also as sources of constant-frequency alternating current.

The new method of frequency measurement herein described depends likewise on the vibration of a tuning fork. However, unlike the tuning forks in the methods noted above, the tuning fork is *driven by the system frequency* rather than being allowed to vibrate freely.

The mathematical analysis of this type of forced vibration is well covered in the text-books (see Timeshenko, "Vibration Problems in Engineering"). If a resonant mechanical system, such as a tuning fork, is so mounted as to be free to vibrate and a sinusoidal disturbing force is applied, the resulting motion may be predicted mathematically. When the disturbing force is of much lower frequency than the resonance of the fork, the motion will be in phase with and proportional to the disturbing force. Also, if the force is of much higher frequency, the motion will be small and 180° out of phase with the applied force. When the applied frequency is exactly the same as the resonant frequency, the resulting motion is limited only by damping or resistance in the mechanical system and is 90° out of phase with the disturbing force. In the narrow frequency band corresponding to the resonant peak, there is rapid shift in the phase angle between driving force and fork motion. Over a narrow frequency band this phase angle is *proportional to the deviation* of the applied frequency from the resonant frequency of the tuning fork.

The new frequency measuring method makes use of this phenomenon by measuring the phase angle between the motion of the fork and the applied line frequency to obtain an indication of that frequency.

OPERATION

Fig. 1 is a schematic diagram of the elements (electrical and mechanical) of the new method. Like the conventional frequency meter, it requires only a single connection to the 110- to 120-volt 60-cycle circuit whose frequency is to be measured. The largest part of the load imposed on the system goes toward heating the cathodes of the two electron tubes used in the phase-angle measuring circuit. (In cases where loading is important, this power, here supplied through transformer T_1, could be supplied by an auxiliary source.)

The voltage which appears across the neon glow lamp is used in the actual measurement. This voltage, because of the neon lamp and the series resistor R_1, has a square wave shape. This squaring off of the applied wave shape tends to reduce the effect of line voltage variations and also to reduce the effect of harmonics present in the applied power. This voltage is applied through resistor R_2 to a small coil which, acting with a small magnet mounted on the end of one arm of the tuning fork, produces vibration of the fork at the frequency of the applied power. The voltage across the neon glow lamp is also applied through transformer T_2 to the Type 7A6 full-wave rectifier tube.

A second magnet is carried on the other arm of the fork and generates in its coil a voltage corresponding to the motion of the fork. This voltage, roughly tuned by capacitor C_1 and the primary of transformer T_3, is applied through transformer T_3 to the control grid of the Type 7C7 tube. This voltage is sufficiently high that the 7C7 is made alternately conducting and non-conducting on the positive and negative half-cycles respectively and, since this tube is connected in the cathode return circuit from the Type 7A6 rectifier, it effectively controls the rectifying action.

When the power line frequency is exactly 60.00 cycles per second (the same as the resonant frequency of the tuning fork) the 7C7 tube is turned on in the exact center of each positive half-cycle and off in the center of the negative half-cycle of the current flowing through the 7A6 tube. Then

tion of the rectified positive half-cycle which flows through resistor R_3 is just equal to that portion of the rectified negative half-cycle which flows through resistor R_6. Under this condition there will be no current flowing through the indicating instrument, which will stand at the mid-scale point marked 60 cycles.

When the line frequency changes from 60.00 cycles, the phase angle of the fork motion and therefore the phase angle of the generated voltage and of the operation of the 7C7 tube, will change correspondingly. This will disturb the balance between the rectified quarter-cycles of current flowing through resistors R_3 and R_6. It will produce a resultant difference in current, either positive or negative depending on the frequency being either higher or lower than 60.00 cycles. This difference in current, flowing through indicating instrument A, will give an indication of the power line frequency.

Resistors R_4 and R_5 serve to adjust the sensitivity of the circuit. The switch shorting out resistor R_5 therefore gives a choice of frequency ranges on one indicating instrument. (In a commercial embodiment of this method there are two ranges, one being 59.75 to 60.25 cycles per second, the other—the more sensitive scale obtained with the switch closed—being 59.875 to 60.125 c.p.s.)

Adjustable rheostat R_7 is provided for calibration of the instrument and to compensate for any slight frequency deviation in the tuning fork or phase angle deviation in the transformers.

ACCURACY AND STABILITY

The accuracy and stability of the phase angle measuring circuit determine the characteristics of the complete instrument. However, errors in this circuit show on the scale deflection directly, so at most are of 1/120 the significance in the absolute frequency indicated. Factors such as tube characteristics are of secondary importance. Changes in the resistors are likewise secondary since all resistors are of the same type and possess similar characteristics, so that practically all changes cancel out.

The stability of the tuning fork, which is the basic standard in this frequency meter and also the circuit, is such that the over-all precision of the instrument is limited only by the precision of reading the instrument's scale. The smallest scale divisions may, for instance, correspond to 0.005 cycle per second (and they do in a commercial embodiment) so that on a 60-cycle mid-point scale a precision of one part in 12,000 is obtained without estimating fractions of a scale division.

This stability of the tuning fork is obtained partly from its form and method of mounting and partly from the material used in the vibrating tines. Fig. 2 shows the construction used in one embodiment of this frequency measurement method. The tuning fork is supported by an extremely flexible tang connection which eliminates to a great extent the transmission of vibration from the base to the fork. This minimizes loading of the fork, thereby reducing the effective damping and increasing the sharpness of the resonant peak.

The frequency stability of the tuning fork is obtained from the material used in the vibrating tines: a special Invar-like material known as Maginvar, which was developed by the General Electric Research Laboratory specifically for use in tuning forks. Since the frequency of the fork depends on both the elasticity of the material and its relative length, the material must have well-balanced temperature coefficients of expansion and of elasticity. Tests of some of these Maginvar tuning forks have shown thermo-frequency changes of only four parts per million per degree Centigrade. Unlike the standard Invar alloy, this Maginvar material is magnetic, although in this present application use is not made of this property.

Tests conducted on the instrument illustrated in Fig. 2 showed a frequency drift of less than 0.01 c.p.s. over two weeks at normal indoor ambient conditions. To obtain this, no special efforts were made other than use of similar resistors in the several places and the use of the Maginvar tuning fork. Tests made in the final calibration of the

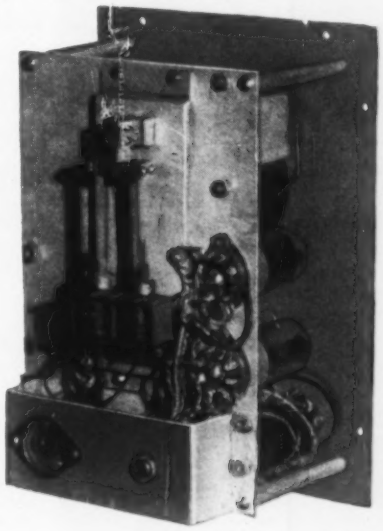

Fig. 2

device indicated that it would be possible to obtain a scale range of $\pm$ 0.01 cycle. However, a satisfactory instrument with this extremely sensitive scale would require a temperature-controlled compartment as well as particular attention to all of the circuit components, in order to eliminate drift and errors.

The mid-scale point of the instrument is determined by the resonant frequency of the tuning fork used. Thus, with a 100-cycle fork, a scale of 99.5 to 100.5 c.p.s. might be obtained, or with a 25-cycle fork a scale of 24.90 to 25.10 c.p.s. This present frequency meter was marked with a scale of 59.75 to 60.25 c.p.s. and it was not feasible to obtain a wider scale than this. For other frequencies the scale would cover a corresponding percentage of the nominal value.

INSTANTANEOUS FREQUENCY

Inspection of the circuit, Fig. 1, brings out that the relatively quicker period of the indicating instrument and a tendency to indicate instantaneous rather than average frequency, will cause this frequency meter to be much more active than the usual instrument. During the tests and calibrations of the device, this was verified. It was noted that this instrument is much more active than the usual frequency meter, that is, the pointer appears to continually move up and down the scale whereas

the usual instrument shows a more steady value. The reason for this lies in the response of the instrument to the varying instantaneous frequency applied to it from the power system.

Immediately following an exceptionally sudden change in frequency, the tuning fork continues to vibrate in its previous mode; but the applied power appears in a slightly different time arrangement due to the frequency change. This results in a change of phase angle between line voltage and fork motion which the instrument indicates as a change in frequency. The tuning fork then slowly takes up its vibration at the new frequency, and a corresponding phase angle, again indicating the applied frequency. Thus the instrument indicates quick changes due principally to a change in line frequency while the previous fork frequency is still

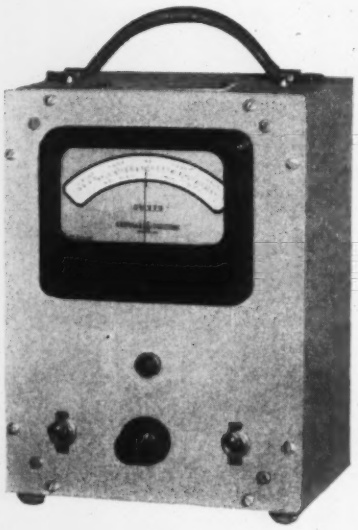

Fig. 3

maintained, and it indicates slower changes in frequency due to the shift of the phase angle of vibration of the tuning fork.

At any point in a distribution system, this instantaneous frequency is equal to the base frequency of the generating unit plus the rate of change of phase angle caused by load changes through the transformer banks and transmission line impedance. The instantaneous frequency at any point may thus change much more widely and more rapidly than speed changes can occur in the generating unit. This concept of instantaneous frequency being proportional to rate of change of phase angle is not new, but it usually has been of secondary importance in power system work.

APPLICATION

This supersensitive frequency meter was developed to satisfy the needs of research work on steam turbine governors. For this work a frequency record was desired as a measure of the speed of the turbine. In the circuit diagram, Fig. 1, a jack is indicated in series with the indicating instrument. This jack is provided in order that a recording microammeter may be plugged in to replace the indicator. For the turbine records it was decided to have the frequency recorded as a function of the governor position. Therefore, the recording microammeter was provided with a tilting chart carriage; and a cord connected to the governor arm served to rock the chart carriage back and forth, corresponding to the position of the governor. After a number of load changes, the recorder fills in a portion of the chart, and this inked-in portion corresponds to the "dead band" of the governor.*

In addition to its original purpose, this supersensitive frequency meter may find application in connection with power system load control when it is desired to change the loading on generating stations in response to extremely slight changes in generated frequency.

This new supersensitive frequency meter is therefore made available in a commercial model as shown in Figure 3. This is a completely self-contained unit approximately 5″ by 7″ by 10″ high. Two scales are provided, selected by a toggle switch —one scale marked 59.75 to 60.25 c.p.s. and the other more sensitive scale from 59.875 to 60.125 c.p.s. A receptacle on the back is provided for connection of the 110- to 120-volt 60-cycle circuit being measured, and a phone jack connection is provided for an external recording element. The entire operating power of the instrument is approximately 5 volt-amperes at nearly unity power factor as compared with 4.7 va., the smallest burden of any of the usual frequency meters. Use of auxiliary power and additional receptacle would reduce the burden to approx. 0.5 va.

*Editor's Note—This governor-performance analyzer is described by R. Sheppard and E. Concordia in *A.I.E.E. Transactions*, Vol. 61, 1942, pages 393-394.—M. F. Behar

ANNOUNCEMENT

Smaller Size to Save Paper

Beginning with the March issue, the trim size of *Instruments* will be

8⅛″ wide, 11¼″ deep

(Type page remains 7″ × 10″)

This is in accordance with WPB Order No. L-244 reducing by 10% the amount of paper available to publishers this year. The new "war size" will make the margins much smaller, without affecting the size of the type page. Subscribers may rest assured that the information presented to them will continue to help them in their work and aid them to go

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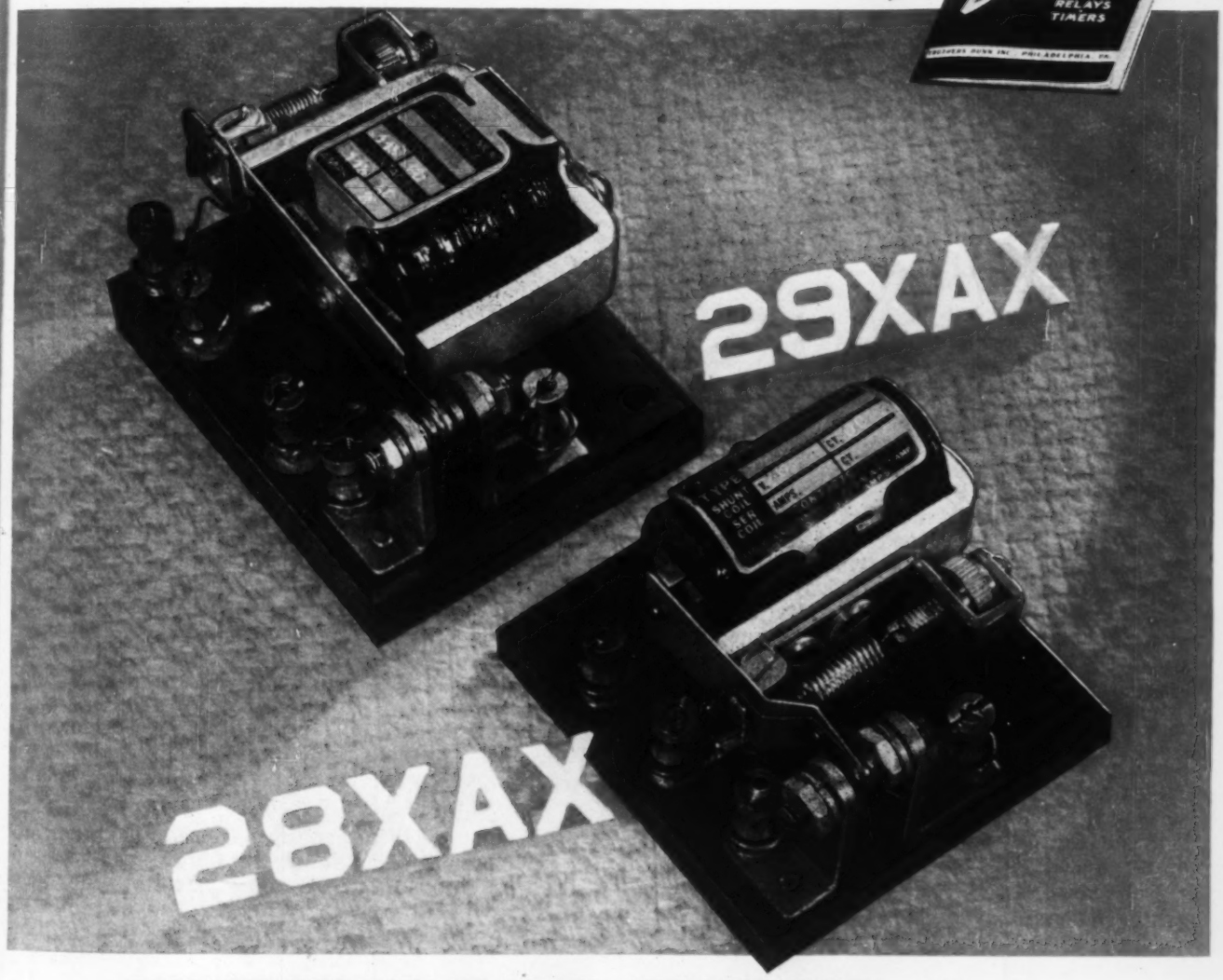

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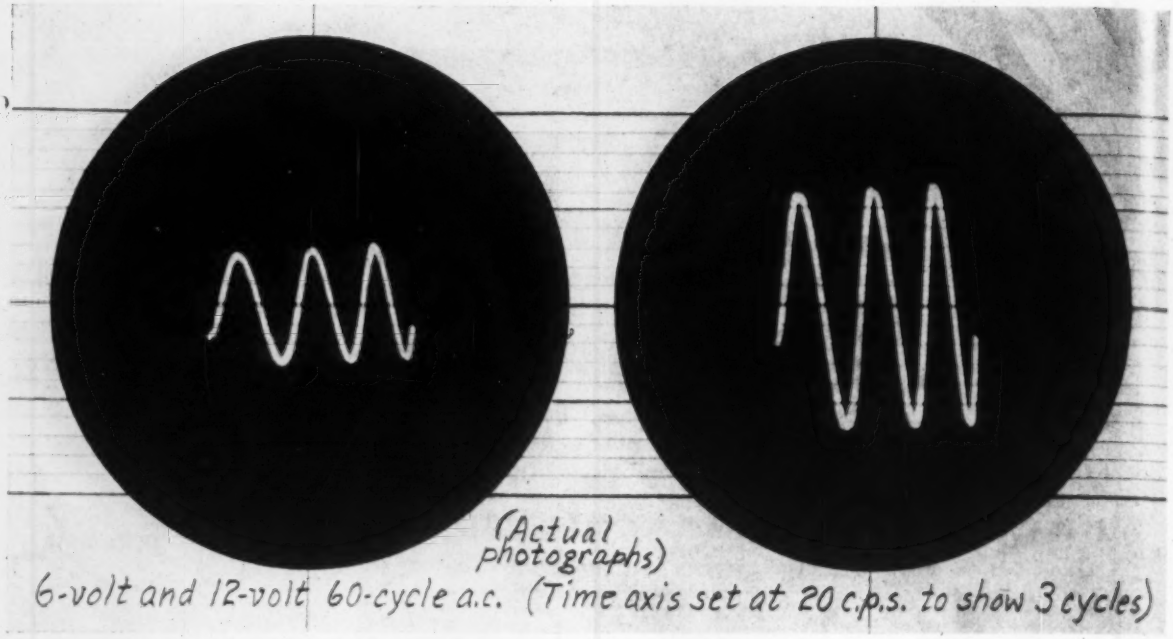

Oscillograph Speeds Up Training of Electrical Instrument Mechanics

By MILTON D. JACKMAN

Instructor-in-charge Radio Division, Signal Corps Section, New York School of Aircraft Instruments

IN the study of electricity many students have great difficulty in understanding the action of alternating current. The customary method of exposition comprises drawing blackboard diagrams and giving a complex wordy explanation. This method tends to confuse the student rather than to aid his concept of alternating current.

By the use of the cathode-ray oscillograph, alternating current principles can be demonstrated in a most graphic manner. This oscillograph is constructed around a cathode-ray tube. A stream of electrons shooting from its electron gun onto the tube's coated inside screen causes this screen to fluoresce in a greenish glow visible outside the tube. By suitable controls the electron stream may be concentrated into a small spot. By reason of the principle of persistence of vision, the motion of this single spot at great speed causes the illusion of the trace line.

The current to be studied is connected to binding posts from whence it flows into the electron-stream deflectors of the cathode-ray tube. As the periodically-deflected stream traces a glowing path on the screen, it helps to dispel such meaningless words as "current amplitude," "frequency," "wave-length" and "phase."

For classroom use, a good adjunct to the oscillograph is some type of transformer with a variable secondary. In these days of scarcity one may be improvised from a toy transformer. Connect the transformer to a source of 60-cycle alternating current. Connect the two leads from the secondary to the vertical deflection posts of the oscillograph. By manipulating the vertical gain controls, the waveform of 60-cycle alternating current can be pictured. Another demonstration utilizes a simple hand-crank magneto, more commonly called a booster. Connect the leads from the booster to the vertical deflection posts. By varying the speed at which the booster is cranked, the number of cycles can be varied.

To show the strength of current or its amplitude, we again make use of the toy transformer. Connect it once more to a source of alternating current. Then connect the variable secondary leads once more to the vertical posts of the oscillograph. Adjust the height of the sine wave one-half inch above and below the zero amplitude line. This is accomplished by using the vertical gain control. This sine wave should represent the current drawn from the 6-volt tap of the transformer. Increase the setting to the 12-volt tap, or to twice the first voltage if the transformer does not have these steps. Measure the loop height from the zero line to the peak of a wave. The height should now be one inch for 12 volts. Increase the voltage to 18 volts: this should result in a loop 1½" high. This height above the zero line is called the current's amplitude. A high loop means a strong current; a low loop means a weak current or low amplitude.

Frequency in alternating current is the number of cycles that occur in one second. Frequency is not affected by current strength or amplitude. When we say high-frequency current, we do not mean that the current loop is high above the zero line. High frequency rather means a high number of cycles per second; in other words a high rate or a high speed. To demonstrate frequency on the screen a microphone and audio-transformer can be used to great advantage. Connect one microphone lead to the terminal of a C battery. Connect the other battery terminal to the primary lead of an audio-

transformer. Connect the other microphone lead directly to the other primary connection of the transformer. Connect the secondary leads of the audio transformer to the vertical posts of the oscillograph. By utilizing different types of sound sources, frequency may be demonstrated. A Galton whistle calibrated at various pitches may be used to demonstrate that increase in frequency is merely another name for increase in pitch. Another good source for this type of demonstration can be obtained from the leads of a phono pickup arm connected to the vertical posts. By using various types of records one may find a limitless number of frequency patterns and one may vividly introduce the subject of harmonics from analogy with musical sounds—the field where the term "harmonics" originated.

With a small amount of practice the image on the screen may be successfully photographed. Such photographs are called oscillograms. The best type of film to use is one that is sensitive to blues and greens. Super-plenachrome can be adapted for this work. A camera with a 4.5 lens and a bellows that permits a working distance of 10" to 18" is suitable. The lens should be used wide open because high speed is desirable and depth of focus is of no importance. The use of a lens slower than 4.5 is not recommended on moving patterns. The shutter speeds can be chosen in a range from about one-fifth of a second to a half-second depending upon the movement on the screen.

The oscillograph may be employed as an alternating current voltmeter. By its use, the peak-to-peak value of an unknown voltage may be determined. The frequency and timing controls properly synchronized will "freeze" many wave-forms on the screen for extended examination, analysis and measurement. By using the horizontal gain controls, the wave-length of any current may be shown.

No article dealing with the operation of the cathode-ray tube is complete without the following caution to the operator: Do not allow a small spot of high brilliancy to remain stationary on the screen for any length of time, as discoloration or burning of the screen will result.

By the constant classroom use of the oscillograph each instructor will find many and diverse other sources of illustrative material. Too much cannot be said of the value of the oscillograph in classroom demonstrations. By its use the student is introduced to one of the most versatile units for the analysis of electric current.

USEFUL REFERENCE TABLES DEP'T

New American National Standard Screw Threads for Gas Cylinder Outlet Valves

ONE of the important safety principles is to prevent all accidents which are inexcusable because they are *completely preventable.*

One of our important friends in Washington urges us to call our readers' attention to the standardization of gas cylinder outlet valve thread sizes. Observance of this standardization in any plant, department or maintenance base, will completely prevent cross-connection accidents in that plant, base or department. The ten types of gas cylinders now have five standard sizes as shown in the table below.*

Note that all threads, except for anhydrous ammonia, are external. Note also that all threads are right-hand except the one for hydrogen, nitrogen or helium (which three gases do not form explosive mixtures with one another). Chief purpose of these standards is to prevent cross-connections of equipment used with a given type of valve, with another type where such may be dangerous or undesirable. As always, a purpose is to promote interchangeability among threads of a given type of valve.

These thread sizes are in agreement with Federal Specification WW-V-61, Feb. 26, 1940, "Valves, Cylinder; Oxygen (for Standard Industrial Cylinders)," and with Navy Department Specification 45V13d, November 1, 1940, "Valves, Cylinder (Gas, Compressed and Liquefied)." —MFB

*Essentially Table 66 in the 1942 "Screw Thread Standards for Federal Services" (National Bureau of Standards Handbook H28) with certain amplifications to save the reader from referring to other pages of that book.

Type of cylinder valve	Dia. of threaded part	Th'ds per inch	Thread type	Class of fit	Major diameter		Pitch diameter		Minor Dia. Max.	Thread length Min.
					Max.	Min.	Max.	Min.		
Oxygen, carbon-dioxide, or air	0.903"	14	Am. Natl. form, special pitch	3	0.9030"	0.8932"	0.8566"	0.8530"	0.8154"	5/8"
Hydrogen, nitrogen, or helium	0.830"	14	Am. Natl. form, special pitch (left-hand)	2	0.8300"	0.8200"	0.7836"	0.7786"	0.7424"	5/8"
Acetylene	0.835"	14	Am. Natl. form, special pitch	3	0.8350"	0.8290"	0.7780"	0.7740"	0.7368"	5/8"
Ethyl-chloride	1/2"	14	Am. Natl. pipe thread, special form		0.8350"	0.8290"	0.7780"	0.7740"		
Anhydrous ammonia	3/8"	18	Am. Natl. taper pipe thread (internal)							
Dichlorodifluoromethane	3/4"	14	Am. Natl. pipe thread, special form		1.031"	1.025"	0.9717"	0.9677"		

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"I LIKE SPEED, but when I fly I want to *know where* I'm going. That's why I want the best precision instruments I can get—instruments I can trust, no matter how tough the going. Then I can use my plane in all kinds of weather, to go *where* I want, *when* I want. After all, *utility* is what you want in an airplane."

MADE TO TOLERANCES as close as .00001", the moving parts of some Kollsman instruments are so precise and must operate at such temperature extremes that the finest oil is too heavy for them. Hence, the gear pinions are set on jewel bearings to insure almost frictionless operation, with plane vibration replacing lubrication.

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Vol. II, No. 2 GUEST EDITOR: E. G. CHAPMAN February 1943

"ON-THE-JOB" TRAINING

Editorial by **ELDEN G. CHAPMAN,** *Guest Editor*

Foreman, Aircraft Instrument Repair; Coördinator of Training, Spokane Army Air Depot, Spokane, Wash.

THE subject of aircraft instruments appears rather obscure to the individual who has never had time or opportunity to investigate it. In large measure this can probably be attributed to the natural psychological effect produced by a purely superficial acquaintance with any subject. There are many who, though constantly working around instruments and knowing of them as a part of aircraft equipment, have never examined the working mechanisms and do not really understand them. Examples: the average pilot, the average bombardier, most gunners and even most ground mechanics other than instrument mechanics. This situation has been largely unavoidable because instruments are overhauled only by certain specified personnel in special shops, because most of these special shops are not always convenient for inspection, because these shops are usually restricted—and because of similar reasons. To these relatively few workers the task of repair and calibration is rightly assigned, for it takes skill and experience to handle and adjust the delicate parts and to operate the necessary equipment.

Dr. Chapman (yes, he has a doctor's degree) was born July 9, 1903, in Brownington, Vt., of Nova Scotia parents. Orphaned at six months, he was passed around to rather distant relatives, so that he began to travel around when rather young and went to many schools for his primary and secondary grades. Then he attended the Mount Hermon School for Men, Mt. Hermon, Mass., 1925 - 1927, New Hampshire University, Durham, N. H., 1928-29, receiving the degrees of B. Ed. and B. Sc. He entered the U. S. Navy in 1929, going to Radio School, Photography, Optics, Navigation. He attended Columbia University in 1931 and did special work while stationed in N. Y. Later took extension work leading to Ph. D. in Ed. Retired from the Navy in 1935 on partial disability—an accident received in service. Finished Doctorate in 1935. Associate to Mr. D. Lybrand of the Washington Institute of Technology, College Park, Md.: research on instruments, 1936-1937. Went to Alaska, worked in aviation and radio, associated with Col. Ed M. George. Returned to Seattle July 1940. Electrical and Instrument work. Loaned to set up instrument classes for National Defense Jan. 1941. Chief Instructor Aircraft Instruments, Rainier School, Vocational Education National Defense, Jan. 1941 to May 1942, Seattle, Wash'n. Chief Instructor Aircraft Instruments, War Production Training, Edison Vocational School, Seattle, Wash'n, May to Oct. 1942. Since then, work at Spokane Army Air Depot may be described as setting up laboratory and shops for training mobile units of the Air Corps. He is an active flyer and a Training Officer in the Civil Air Patrol.

On the other hand, one must not assume that an understanding of the theory of operation of aircraft instruments is beyond one's capabilities. The physical principles upon which their operations are based are not only fundamental but easy to understand. This will be more thoroughly appreciated if only one realizes that the principles used in the earlier instruments are in practically all instances the same as those which we use in the most modern types. It is true that modern instruments are better constructed and are far more reliable than the earlier types. This is only natural, since the materials and features of design in use today are the results of many years of research and experience. It also is true that some of the newer instruments are based on principles entirely different from those formerly employed, the most obvious changes having been the adoption of gyroscopic and radio principles. Yet the majority of these instruments function basically as did *their* first predecessors. Hence, the simplest basic principles which were first applied are still in use—and as simple.

Producing aircraft instruments mechanics for our war production is as yet quite a problem for many shops. There has been proposed and generally accepted a broad term, "TRAINING ON THE JOB." However, this has been a subject of much discussion and little has been done about it. Therefore, each shop head must design a curriculum himself. This type of training cannot directly be compared to any other. One of the main elements is that we must do this job in the least possible time and do it well. We do not use the term engineering in an instrument shop in its usual sense but, as the training progresses, it involves fields that embrace several types of engineering. It seems that most of the leaders in the field of instrumentation have had

to follow the same route, that is, a devious route through many fields, tying in those parts pertinent to instrumentation. As we are well aware, an aeronautical engineer need not be and probably is not as well versed in instruments as is an instrument mechanic. Conversely, we know that one may not need be an engineer to be an efficient instrument mechanic. But, when we thoroughly analyze this subject, we find the need for an engineering curriculum majoring in aircraft instruments. This type of training must not be confused with the work that the many fine schools, devoting their full time and energy, are able to give. Again, if the instrument mechanic is thoroughly familiar with the construction and operation of aircraft, and is able to pass actual flight tests, we find a more thorough understanding of the difficulties actually encountered. This was well explained in the article by Carl Nisbet in the October 1941 issue of *Instruments* and in other articles since then. So many points have been brought up in these fine articles that there is little left to say, except perhaps to suggest that these men might meet in a conference to prescribe a standard curriculum that could be acceptable to all, i.e., scholastic, private industry, and the Army and Navy. If this could be accomplished, the confusion and differences of opinion, would be greatly reduced and a real step of progress made in this profession.

Today's problems arose because of the vital necessity of increasing the volume of production. To increase our production, and to carry on training at the same time, a means of "on the job training" had to be developed. Again, we have to break down the factors in this order: First, the time element—Today we are at war, and have no time to waste. Secondly, we must face the problems of personnel, the problems of the men, draft, enlistments and the natural turnover to other jobs. There is also the inevitable influx of women not accustomed to this type of work. As considerable time has been spent in training men in this particular field, and as it is greatly essential to the armed services, we may consider our loss their gain. Therefore we must work the harder to overcome this obstacle and make greater use of female personnel. Then, too, we have need for "specialization." The meaning of this large word can be broken down many times—possibly we can consider Henry Ford as the person to utilize "specialization" to its perfection. However, I believe that in instrument repair, the personnel will never be sacrificed to this extent. We have a natural turnover. The training in our field must obviously be of a higher order than the many specialized trainings for mass production.

With regard to the time element, schedules must be prepared and strictly observed. In doing this, we have been quite successful in using the vocational "Four-step Method" of instruction and timing and a complete break-down of production outlined by progress charts.

The proper analysis of personnel is of utmost importance in properly assigning them to where they will be most satisfied in their own minds that they are properly placed. This is a large order and perhaps more trained psychologists should be employed as personnel directors. We have been able to follow a few simple *(Continued on page 72)*

Operation of Vacuum-operated Automatic-pilot Air Pick-offs

By LEONARD M. FAIKE

Supervisor, Instrument Repair, Spokane Army Air Depot, Spokane, Wash.

CONSIDERABLE confusion exists among learners and more experienced aircraft instrument mechanics in regard to the actual operating principles of the air nozzles in relation to the pick-off plates.

Most prevalent misconception is the belief that an aircraft flying with the automatic pilot engaged will, after being disturbed by some atmospheric condition, return to the original heading in a single smooth movement of the follow-up system.

This is an erroneous assumption, for the return to course is accomplished by a series of successive actions, the rapidity of which is governed by the hydraulic speed control valves and the number dependent on the degree of displacement.

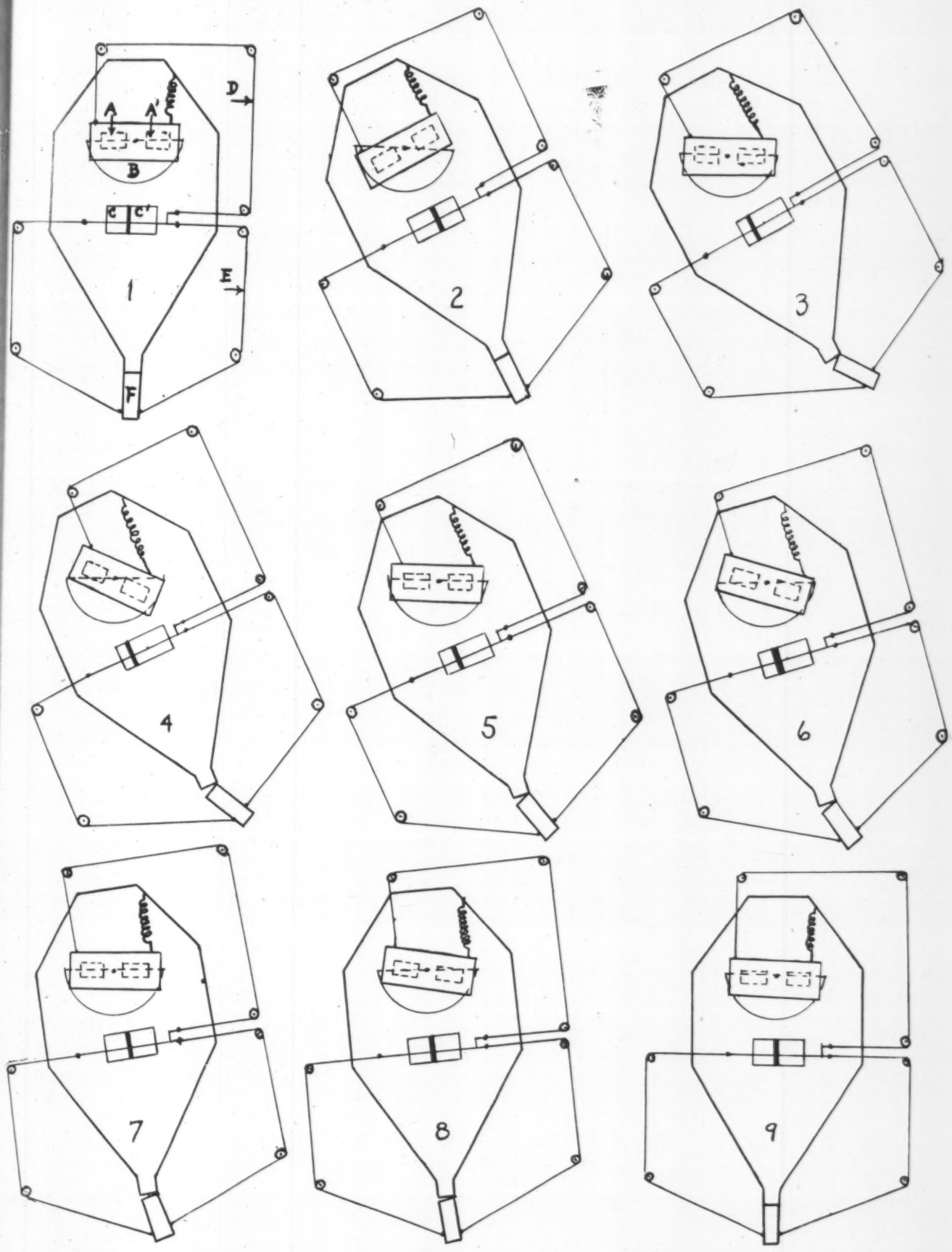
For a more clarified illustration, the exaggerated schematic outline of a fuselage containing the air nozzle, pick-off plate, follow-up cable and servo unit has been incorporated to explain rudder control. To eliminate complicated drawings the additional accessories, tubing and rigging must be visualized by the reader.

Example 1 illustrates an on-course condition with the air nozzle ports *A* and *A'* bisected by the pick-off plate *B*. *D* represents the follow-up cable, *E* the main control cable, and *F* the rudder.

In example 2 we assume that some disturbance has thrown the aircraft off course, allowing *A'* to be fully open and *A* fully closed. This in turn displaces the air relay and balanced oil valve, permitting hydraulic pressure to be exerted on the *C'* side of the servo unit.

Example 3 illustrates the servo cylinder hard over, putting in corrective rudder control and moving the follow-up system until once more *A* and *A'* are bisected by *B*.

LEONARD M. FAIKE is a graduate of the American School of Aircraft Instruments, Glendale, Calif., and of the Sperry Gyroscope Co. School, El Segundo, Calif. His practical experience was acquired "the hard way" at the Lockheed-Vega Aircraft Corp., Burbank, Calif.; at the American School of Aircraft Instruments, Glendale, Calif. (as an instructor); at the Spokane Army Air Depot, Spokane, Washington; and at the Sacramento Army Air Depot, Sacramento, Calif. Though only twenty-six years old, he is respected as an old-experienced aircraft instrument technician. —ELDEN G. CHAPMAN



The air force created by the aircraft's forward speed is exerted on the rudder surface and in turn swings the aircraft back toward the original heading. As this occurs (example 4) *A* and *A'* become unbalanced, allowing hydraulic pressure to be exerted at *C*, thus moving the servo cylinder, rudder controls and follow-up system until condition 5 is reached.

From this point, explanations identical to those for examples 3 and 4 are repeated until gradually all rudder control is removed and the aircraft has regained the original heading, example 9 or 1.

Trouble Shooting on the Flight Line

Procedure for Electrical Instruments

By Senior Aircraft Instrument Mechanic LeROY J. POSPISIL
Foreman, Instrument Laboratory, Paine Field, Wash.

IT is the writer's personal conclusion, drawn from experience over a period of years, that few men know how to do an intelligent job of trouble-shooting in the field of electrical aircraft instruments. Without going into the theory of operation of the different types of instruments, an attempt will be made to describe the troubles most commonly encountered on the flight line and to give a procedure for the definite location of these troubles with minimum equipment in minimum time.

The first sign of trouble will be an erratic action or indication, either intermittent or continuous, or no indication at all. Since there is, in most cases, more than one electrically-operated instrument in any one installation, it is natural to assume that if all the instruments have erratic or no action, the trouble is general in nature and can usually be traced to failure in the main battery circuit if it is found that other equipment, such as lights, fail to function. This can be caused by a discharged or disconnected battery, defective switches, solenoid, or cables, or a battery connected improperly as to polarity. If all equipment other than instruments functions properly, it will be necessary to check instrument fuses for fusion or failure and it will be from this point that the trouble-shooting will begin.

Instruments using the ship's direct-current supply directly are the resistance and ratio type thermometers, fuel-air ratio indicators, wheel and flap position and fuel level indicators. The resistance type thermometers and the fuel-air ratio indicators employ a hot wire resistance bulb to stabilize voltage and this bulb should be checked for failure before looking for trouble elsewhere. Instruments that energize their own individual systems (i.e., that are complete in themselves) are the thermocouple indicator circuits, and the several types of tachometer generator indicator circuits.

In multi-motored ships where engine installations are remote from the pilot's or engineer's compartments, the necessary engine indications are all transmitted to the panels by remote-reading self-synchronous electrical instruments. Although these systems usually employ alternating currents obtained from inverters which operate from the ship's d-c. supply, isolation of troubles common to them is accomplished in the same manner as in the direct-current systems, as far as flight line trouble-shooting is concerned. Wheel and flap position and fuel level are indicated remotely by both alternating- and direct-current systems.

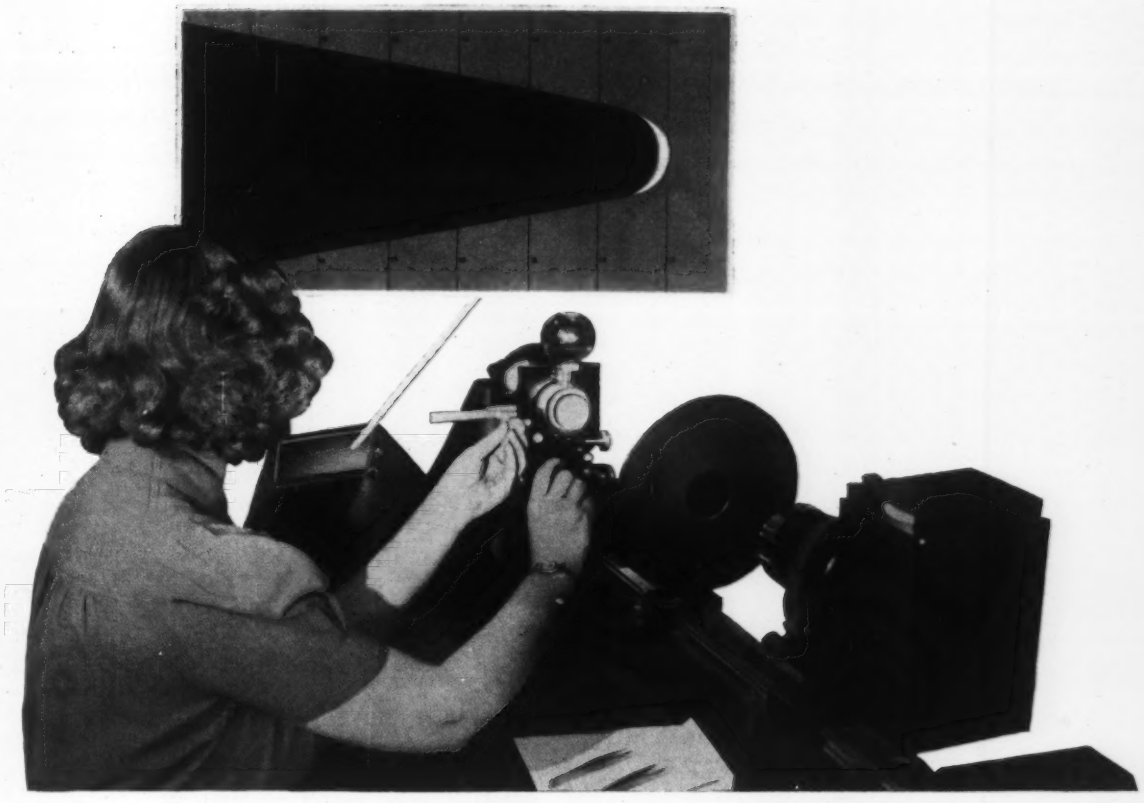
Analyzing these electrical systems, they are found to consist of three basic units or parts. First—the transmitter or unit actuated by pressures, temperatures or positions; second—the receiver or indicator that translates the electrical impulses or voltages from the transmitter into the desired information; and, third—the necessary connecting wiring between the transmitter or bulb and the indicator. It is possible, by systematically eliminating each unit as a probable source of trouble, to isolate and discover the cause of faulty operation in the least possible time. The faulty operation should be definitely traced to the indicating or transmitting unit before that unit is sent to the repair shop.

Before work is done on a ship, it should be determined whether it has just come from the shop or directly from a flight. If the ship has come from the shop where an engine change or other work has been done which has necessitated breaking the circuits at the disconnect plugs or terminals, closely check the connections in question for improper connection. It is easy for an inexperienced person to dismantle the plug itself when attempting to disconnect it instead of turning the locking ferrule and then, in reassembly, to force the plug together in an incorrect manner, thereby causing cross-connections in the circuit concerned. The disconnect plug itself can be forced into its socket a quarter or half-turn from its proper position, thus causing erratic operation and possible injury to the instruments and their interconnecting leads. This has happened many times.

If it is found that trouble (either intermittent or continuous) has developed in a particular circuit in flight; and if all connecting leads check for continuity, the trouble is often found to be in the connectors in the disconnect plugs. If the ship has seen considerable service, these connectors are sometimes found to have become corroded to the point where continuity is impossible. Mishandling and metal fatigue can also cause the part to fit too loosely to make a good electrical connection. Where voltages are low and currents small, every connection must be perfect. In this case, it may only be necessary to clean and rework the plug in question to put the ship back in service. It is surprising how often erratic indication can be traced to faulty connections between instruments and their circuits, usually caused by careless handling of the plugs.

Once it has been definitely established that the circuit and its connectors are serviceable, if indication is still erratic the next step is to determine the serviceability of the transmitter or bulb, for these units are the ones that most often break down in service. This can be traced to the fact that they are located near the engine installation and are subject to more vibration and temperature changes than their corresponding indicators on the instrument panel. In a remote-indicating engine instrument the transmitting unit is necessarily more complicated mechanically, thus offering more opportunity for "bugs" to develop. Although the electrical part of the unit may be intact, the actuating mechanism of the transmitter proper may have become defective due to wear or accident. Where similar units of known accuracy are available, it is a simple matter to substitute one in the circuit for the particular instrument in question. By manually operating this substituted transmitter, it can be determined definitely whether or not the transmitter in question is the cause of the trouble. On some

(Continued on page 77)



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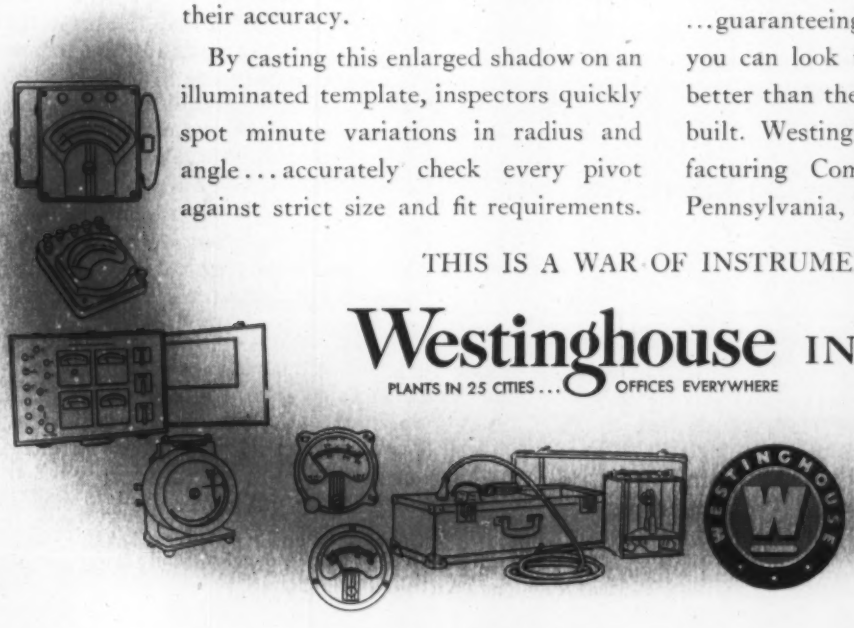

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"Production" *vs.* "Employment Problems"

A Practical Suggestion Which Has Proven Successful

By FRED H. BROWN

Foreman, Instrument Repair, Spokane Army Air Depot, Spokane, Wash.

PRODUCTION and the repair of aircraft instruments, until the war, were never considered in the same category. Instruments were repaired by highly skilled instrument mechanics. These men were not specialists but, rather, were able to overhaul both pressure and electrical instruments. Several years back the arrival of the gyro and the increased number of both pressure and electrical instruments started the trend toward specialization. Instrument shops were set up in three departments: pressure, electrical and gyro. Mechanics at this time were able to repair and calibrate all of the instruments within their departments. By this means they became specialists and were able to turn out their work faster and more efficiently.

Time and demand have now made another change in many of the larger shops. Because of the desperate need for repaired instruments, mechanics are being trained and put to work on one, two or three instruments. This decreases the time spent for training and increases the efficiency of the new employee. Even with all of the short cuts which have been taken in an effort to fill in the vacancies, the personnel being received or available is, at best, only partly trained. This is due largely to the shortage of time allotted to the trade schools and other training centers. The Armed Forces have drawn many of the skilled men into the service for overseas duty. This drain of men, who have not been replaced, has left many a foreman behind the well-known eight ball. It has become the problem of the foreman and of the personnel director to place the new personnel in the shop where their varied abilities can be used to the best advantage—this being probably the most important factor in determining the magnitude of production obtainable in the future.

Perhaps one solution to this problem is to create a new position in your shop. It will call for one of your better men but his time will be well spent and the results of his work will be noticeable. Sit down and go over your personnel list, noting particularly which of your better men have the following traits:

Adaptability to new methods,

ability to coöperate with his fellow workmen,

ability to produce and

ability to conceive new and practical ideas.

After you have found him it would be wise to give him the following duties. He would go through the shop working in the different departments, noting in each all of the changes he would deem necessary to make the shop more convenient for the men to work in. I mean by this, some test apparatus is possibly placed in the shop so that it is inaccessible, or a valve may be such that it requires the mechanic to take his eyes from the manometer to make the necessary adjustment, or a manometer may be so placed that it congests a certain part of the shop with too many people. Inconveniences of all kinds, personal or otherwise, slow down production. He would also make a job analysis of the various types of instruments, studying the time for each operation and the skill involved. After his survey and report have been made, it will be found that you have many jobs in your shop which require much time but little experience. It is with this report that you can easily place some of the less-trained employees. Then, as they become accustomed to the shop and, through their own initiative improve their knowledge of the repair of certain instruments, gradually move them into the regular overhaul and calibration work.

A few of the shops have put this idea into practice and have found that they were able to break in the prospective mechanic without loss of time and money. It also gives you time to study the new mechanic before placing him in a key position, thus avoiding possible mistakes in judgment which easily could cause no end of trouble and discontent. You will agree that this, above all, must be avoided if possible.

"On-the-job" Training

(Concluded from page 68) rules with considerable success. Men and women must be considered separately, never as one group. Their mental and physical make-ups are as unlike as the sun and the moon. One must respect the various physical aspects of the women in the shops and the effects upon their temperaments at particular times. Environments should be considered in keeping the morale of the individuals—men and women—at its higher peaks. Their scholastic and practical backgrounds, likewise, must be thoroughly analyzed. Their personalities must be considered, that we may not place persons who naturally may clash in close contact with each other. We then try to discover an aptitude which may be improved through training.

Similar to the word "aptitude" is the word "attitude"—This is an important factor. Not only the trainees and mechanics but their immediate supervisors especially must bear the proper attitude. There will be comments and arguments on this following statement:

Suggestion—The power of suggestion is great, in fact so great as to be associated with hypnosis. Bearing this in mind, that it can create good and evil, we will use it sparingly with great care.

These thoughts have proven to be a great help in the organizing of many classes and shops that the writer has been associated with. Passing now from general principles to concrete examples, the forms shown herewith are used to create an "on the job training" for mechanics, also supervisors and instructors for various departments in our shop.

The chart illustrated in Fig. 1 is used to check each type of instrument. This particular chart is for the gyros and clearly shows the method of

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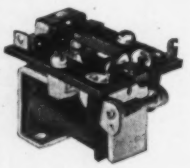

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keeping an accurate check of the mechanics' work and of the individual mechanic who does any portion of that work. It can be used continually through more than one shift in the shop. The original of this chart was proposed by Mr. Ed. McGovern of our gyro department and has been adopted on all instruments throughout the entire shop.

Fig. 2 is the schedule of daily training in conjunction with production. It has proven its value because of its flexibility, and yet we are able to follow timed schedules. The technical orders which are designated on this chart are the procedures of

SHOP JOB NO.____

INSTRUMENT	SERIAL #	TYPE	WORK ORDER
DATE STARTED	**DATE FINISHED**		**SCORSBY**

DISASSEMBLY	MECH.	WORK MECH.	ASS'Y MECH.
CAGE ASS'Y			BENCH TEST
CASE			
DIAL			
FILTER			
GIMBAL ASS'Y			BENCH TEST
			BALANCE
			ASSEMBLY
AIR PIVOT (END)			CONCENTRICITY
BEARING (END)			
PIVOT (CASE)			
BEARING (CASE)			
BEARING (SIDE)			
PIVOT (SIDE)			
POINTER BAR			BALANCE
P.B. BEARINGS			
P.B. PIVOTS			
P.B. GUIDE			
ROTOR ASS'Y			BALANCE
PENDULOUS ASS'Y			CLEARANCE
			START-COAST
UPPER BEARING			
LOWER BEARING			
			DYN. BAL.
AIR PIVOT			CONCENTRICITY
SIDE BEARING			

Fig. 1

A. TRAINING
B. PROGRESS CHARTS — A. M.
1. Group
   a. Fundamentals
   b. Breakdown
   c. Parts inspection
   d. Assembly — 1 hr.
   e. Test and Calibration
1a. Functional test diagnosis
2. Advanced Group
   a. (Detailed procedure)
   b. Basic instruction—all instruments — 1 hr.
3. Visual Education —30 minutes
   Notes and discussion—30 minutes

P. M.

Detail Breakdown
   a. Tools
   b. Equipment
   *c. T. O.'s
   d. Breakdown and repair—detail
   e. Inspection
   f. Assembly
   g. Test—calibration

TEACHER DISCUSSION—(Shop heads)
2 times weekly—constructive criticisms.
*Technical Orders

Fig. 2

disassembly, assembly, repair and calibration prescribed by the Army.

The sheet shown in Fig. 3 is used for constructive criticism of those we designate as instructors.

In Fig. 4 is shown the upper part of a form whose purpose is the break-down of an individual assembly which requires a more detailed explanation. Also, it is flexible enough to be used in conjunction with chart No. 3.

We all agree that there is a great need for competent instructors and supervisors. As has been previously stated, superficial knowledge is not only a detriment to the individual but, if we allow it to be foisted upon a group in the guise of an instructor or supervisor, we allow a shop to deteriorate. We may avoid this by those who are yet available as instructors and supervisors training this personnel. To do this intelligently, we must thoroughly analyze and select the persons who we feel reasonably sure will remain permanently in the shop. Specifically, we must observe the following: *Leadership; Progressiveness; Personality; Appearance; Thorough knowledge of the work.* (Of course the order of these qualities may be changed by supervisors to suit their individual ideas.)

It is a well-known fact that visual education can be used to shorten the training period and in some

CHECK SHEET

For Constructive Criticism of Practice Instruction

1. Was the Instructor adequately prepared? Did he appear to have something to "shoot at"? .....; to have analyzed his job? .....
2. Consider how well the instructor followed the Four Basic Steps:

STEP ONE—*Preparation of the Learner.*
(1) Did he put learner at ease? .....
(2) Did he get learner interested? .....
(3) Did he find out how much the learner already knew? .....
STEP TWO—*Presentation.*
(1) Did he make proper use of Telling? .....
Showing? .....
Illustrating? .....
Questioning? .....
(2) Did he present instruction too fast? .....
(3) Did he keep instruction at learner's level? .....
(4) Did he hold learner's full interest? .....
(5) Did he make presentation complete? .....
(6) Did he get the learner to "think through" the problem? ...
STEP THREE—*Performance Try-out.*
(1) Did he get the learner to correct his own errors? .....
(2) Did he follow correct procedures in bringing out the "key points"? .....
(3) Did he make certain learner had really learned? .....
STEP FOUR—*Follow-up.*
(1) Did Instructor have learner repeat job without assistance? .....
(2) Did the follow-up prove that learner had really mastered the job correctly? .....

3. What was the weakest feature of the Instructor's instructing demonstration? .....
4. What was the strongest feature of the Instructor's instructing demonstration? .....

Fig. 3

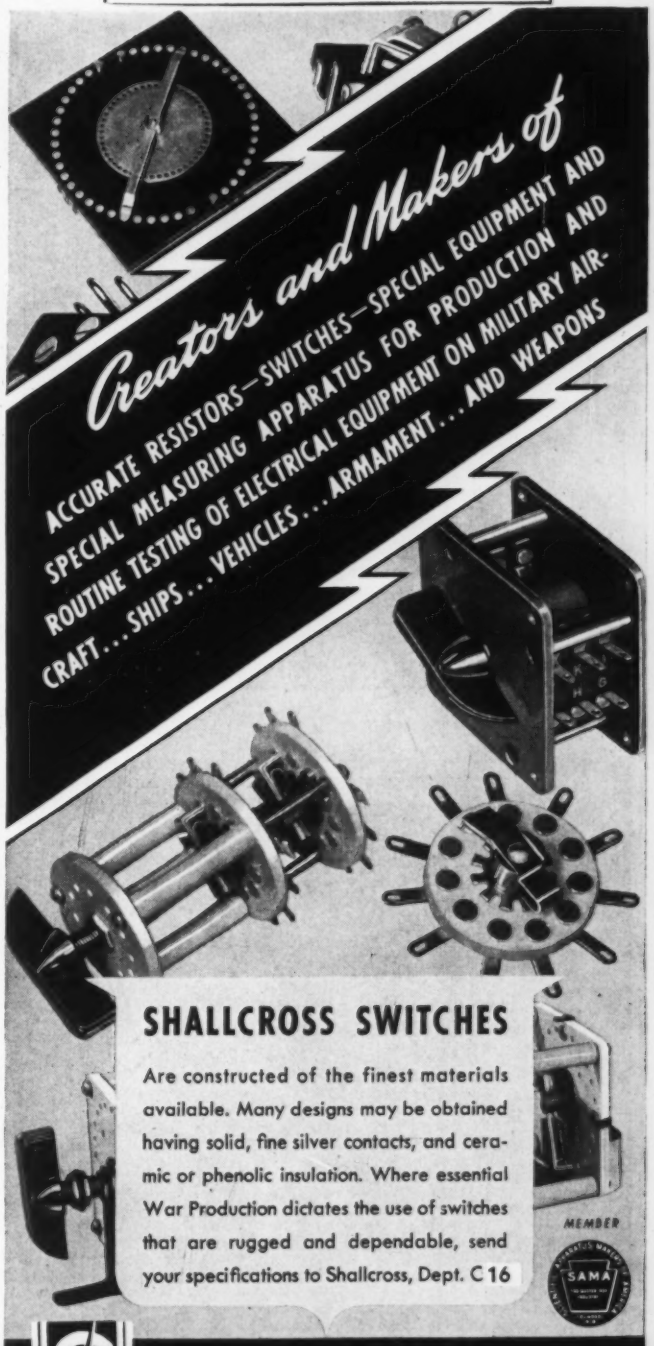
JOB ANALYSIS SHEET FOR
BREAKING IN MAN ON NEW JOB

..... Training Program

Group: .....
Part..... Operation.....

Important Steps in the Operation	"Key Points"—knacks, tricks, timing, special information

Fig. 4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RINSES every trace of dirt
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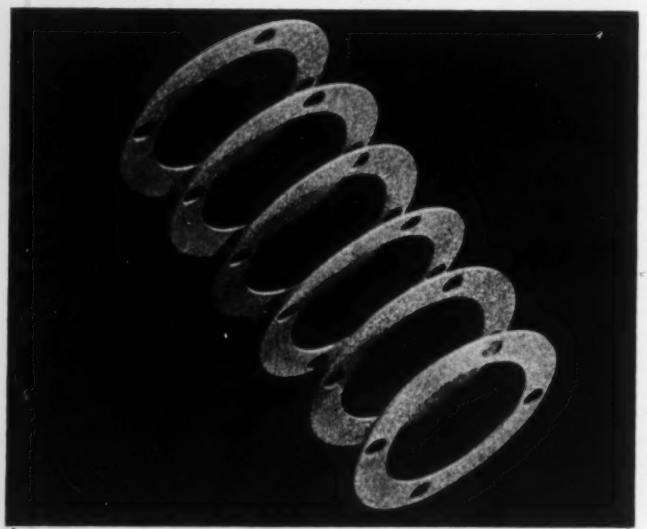

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cases to put across in a few moments shop ideas that would normally take days of instruction by the usual method of lecture and doing. There are available at this time films pertaining to aircraft instruments which greatly aid in teaching the basic principles and the flight conditions of these instruments. When these films are not available (and the supply of those that we may use is very limited) we can make our own by using proper continuity, either in strip film or movie. The cost is little and usually someone in the shop has photography as a hobby and is eager to coöperate. If strip film and movies are not available, we can use the Balopticon or the old-time projection lantern and proceed with our lecture and discussion. At times this method seems preferable to the strip film and movie. (Naturally, it calls for a thorough knowledge of the work from the instructor or supervisor in charge.) Many instrument shops are located close to universities or colleges where they may obtain valuable information and coöperation in compiling film and proper continuity for visual instruction. We find also that aircraft instructors and instrument manufacturers usually are most coöperative in this field as they are well aware of its value. There are texts available on the subject of visual methods. And there are texts on the subject of aircraft instruments if no other means can be used!

Today we find a suddenly-increased personnel in all shops. Therefore we must not only ask but demand the coöperation of all. This can be easily obtained if we return to the proper analysis of the persons in our shop: there must be no exceptions, from those in charge to the beginners. If there be lack of coöperation, even in small degree, the shop will never achieve its purpose.

One hears the word "morale." This comprises many things. Our work is *serious* and we must be serious to accomplish it, but not to the extent that we cannot laugh occasionally. When possible, bring some topic or part of your work into relation with something humorous. (But don't overdo it: our work *is* serious.) The lighting, the shop atmosphere in general, the working conditions at the benches, general comforts of the personnel, will tend to raise "morale." There are many other ways of accomplishing this purpose and the smaller details usually are left to the attitude of the supervisory personnel.

In keeping all channels closely tied and related, it has been found that a progress chart clearly defining and breaking down all work, aptitude and attitude of each individual will help keep an accurate check of the progress of that individual. There are many types of progress charts and many ways of deriving grades to mark these charts; the accepted method usually consists of examinations—written, oral and practical. To arrive at the proper analysis, examinations must be thoroughly studied by the one giving them. It has been found that as much thought must be given by the examiner as by the one taking the exam. This can be attained by introducing short courses in teacher-training.

At this particular time, the many training procedures, instructors and types of instruction in this field have many points in common, yet are extremely far apart. It is hoped that the reader will consider the vastness of these points and will realize that they have only been briefed in this cursorily-prepared article.

Trouble Shooting on the Flight Line

(Concluded from page 70)

single-engined and all multi-engined ships where installations have indicators electrically similar, it is possible by the use of plug-in "jumpers" to connect an indicator from a circuit known to be serviceable to the circuit in question after first having made certain that it is serviceable electrically. With serviceable connecting leads and indicator in the circuit, the cause for continued erratic action is definitely isolated in the transmitter. If, instead, the circuit is found to function with the substituted indicator, the cause of the malfunction is isolated in the original indicator.

This same process of elimination can be used to isolate any causes for trouble arising in wheel and flap position and fuel level indicating circuits, thermocouples, etc.

In the case of wheel and flap position indicating systems, a common cause of trouble can be traced to maladjustment of the mechanical linkage, causing over-travel of the moving element and breakage of stops, with consequent damage to the transmitting unit.

Occasionally a case is encountered where a wheel position indicator or transmitter breaks down in flight by reason of a short circut. The break-down of insulation or terminals at lock switches or in the interconnected warning horn circuits can cause shorts in flight that disappear when the ship returns to the ground. Here it is necessary to retract the corresponding wheel on the ground to simulate flying conditions to cause a recurrence of the short circuit so that it can be traced with the ohmmeter.

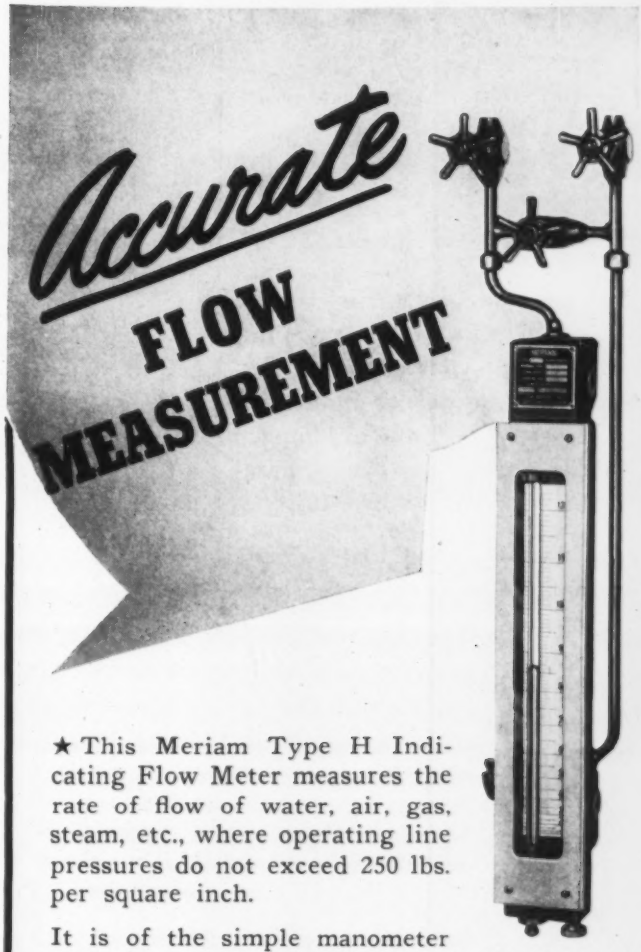
In the case of fuel level indicating circuits, the float assembly which actuates the transmitter has been known to lodge in a full-up or -down position because of sticky tank flushing compound used to protect the tanks from special fuels. Deterioration or sagging of the tank walls themselves can cause enough strain on a float assembly to hold it at points between empty and full.

Any trouble encountered in indicators is usually confined to a sticky condition of the pointers caused by worn or dirty pivots or cracked jewels, weak position or rotor magnets. Such a condition necessitates removal and overhaul.

As a word of precaution: in the event that either a transmitter or indicator unit is found to be faulty because of a burned winding caused by a short circuit, be absolutely certain that the cause of the short circuit is definitely eliminated before installing a new instrument. Now, with replacements so difficult to obtain, every precaution must be taken to prevent such needless damage.

Trouble-shooting in any branch of maintenance offers a challenge to the analytical mind and especially is this true in aircraft electrical instruments now, with the war stepping up the tempo of our times. Intelligent use of the test equipment at hand, no matter how simple this equipment may be, and the application of good old "common sense," can really do a fine job. Time lost by needless removal and replacement of instruments must be kept to the minimum—to zero.

Work, Fight, Give: Make Democracy Live!



★ This Meriam Type H Indicating Flow Meter measures the rate of flow of water, air, gas, steam, etc., where operating line pressures do not exceed 250 lbs. per square inch.

It is of the simple manometer design, rugged in construction, and does not employ any gears, cams or levers in its operation. Consequently, where an inexpensive, accurate instrument is required for either permanent or portable service, it finds many applications.

Available for flush panel mounting or for pipe mounting. An integral return well is incorporated in the unit to prevent the loss of indicating fluid, should the flow range exceed the designed range of the instrument.

Having a maximum differential of 160 inches of water pressure when using mercury as the indicating fluid, the Meriam Type H Manometer can be furnished with standard differential scales or with direct reading scales for specific applications.

For complete information and suggested installation diagrams write for Bulletin 18.

THE MERIAM COMPANY
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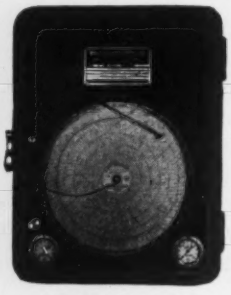
Process Control for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

Combustion Control that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.



Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.

Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

G-3

BAILEY METER COMPANY

1041 Ivanhoe Rd., Cleveland, Ohio

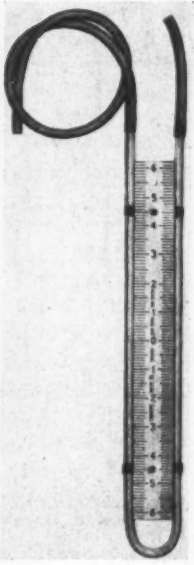
The Month's NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department as your source of information. Or write to Information Section, Instruments Publishing Company.

Rotameter for Hydraulic Oil Flow-rate Testing

New high-pressure "Stabl-Vis Rotameter" automatically compensates for viscosity variations when measuring flow rates of hydraulic oils in testing airplane hydraulic systems and accessories. "Stabl-Vis" principle was fully described in *Instruments*, March 1941, pages 65-68. It makes possible accurate flow rate measurement in spite of viscosity variations in the fluid being metered. Model illustrated is designed for 2,000 lbs./in.^{2} working pressure; other models are available for pressures up to 5,000 lbs./in.^{2}. Flow rate is read directly from a uniformly-graduated scale.—*Fischer & Porter Co., Countu Line Road, Hatboro, Pa.*

Service Type Manometer



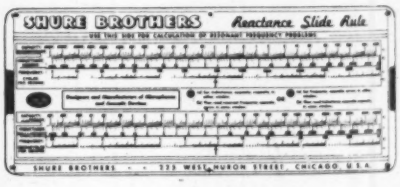
New service type U-tube manometer is announced for field service, experimental and test work and temporary hookups. Standard scales are calibrated in inches and tenths, are easy to read. Specially-calibrated scales are available at no extra cost in large quantity lots. Unit has unbreakable Pyralin U-tubes, is built to withstand rough service; is light in weight, easy to use and designed to use water as the indicating fluid. A 24" gum rubber tube is supplied with each manometer. Sizes 6" to 12".—*Trimount Instrument Co., 408 South Plymouth Court, Chicago, Ill.*

Torque Wrenches

Instead of two dial sizes with calibration ranges either of 0-600 or 0-2200 inch pounds, new torque wrenches are made in four dial sizes: (1) a unit with a two-revolution pointer for measuring 0-150 inch-pounds of tension on an outside scale, first revolution and up to 250 inch-pounds on an inside scale, second revolution; (2) calibration range 0-600 inch-pounds; (3) range 0-1200 inch-pounds; (4) range 0-2400 inch-pounds. With four sizes of dials and the calibration range of each limited, dial graduations are larger, more widely spaced. This makes it possible to read them more quickly and more accurately. Accuracy guarantee is 98%. Mounting of dial is also improved. Set in a special housing inside an extension of the handle, it is more rigid, better protected from shocks.—*Apco Mossberg Co., 156 Horton Street, Attleboro, Mass.*

Reactance Slide Rule

New Reactance Slide Rule speeds up the solution of resonant frequency problems, capacitive reactance problems, inductive reactance problems, coil


SHURE BROTHERS
Reactance Slide Rule
USE THIS SIDE FOR CALCULATION OF RESONANT FREQUENCY PROBLEMS
SHURE BROTHERS • 225 WEST HURON STREET CHICAGO U.S.A.

"Q" problems and dissipation factor problems. On one side, resonant frequency problems are solved with one setting of the slide, with ranges of 5 cycles to 500 megacycles, 0.001 mmf. to 1,000 mf. and .00001 mh. to 10,000 henries. On other side, reactance, dissipation factor and coil "Q" problems are solved with one setting of the slide, ranges being 0.1 cycle to 10,000 megacycles, 1 mmf. to 100 mf., and 0.001 mh. to 100 henries. Available by mail at nominal charge of 10c in coin or stamps to cover cost of handling and mailing.—*Shure Brothers, 225 West Huron St., Chicago, Ill.*

Multiple-contact Timers

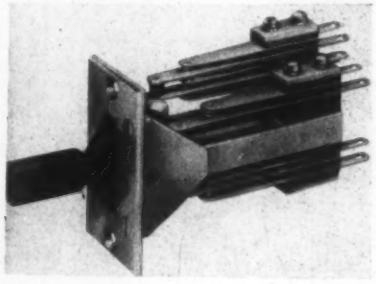
Function of new "Multi-contact Timers" is to control automatically a sequence of "on" and "off" operations of a plurality of electrical circuits (or of one circuit) in accordance with a predetermined operating program. Each unit can control a series of machine operations in definite order; automatically reverse or alternate in operation a group of motors, machines or devices; operate in a predetermined sequence, etc. Features include self-starting synchronous motor, complete gear trains operating in oil, Bakelite cams mounted on shaft in identical pairs so the "off" and "on" increments can be adjusted to the desired operating program. Can be manually operated. Contacts are in plain view. Can be provided with remote momentary starter.—*The R. W. Cramer Co., Inc., Centerbrook, Conn.*

Safety Pressure Controller

Announcement is made of a safety device for manufacturing plants, especially those located in areas in which bombing is apt to occur. Water pressure must be kept above certain limits in order not to become a hazard. Most manufacturing plants use water for cooling purposes, where a drop in pressure will cause damage unless the operator is warned immediately. War production plants are especially liable to two possible causes of pressure drop, aerial bombs and saboteurs. The "Honeywell Safety Device" consists of a pressure controller which will sound an alarm bell on pressure drop. This bell may be located any place in the plant most convenient for the person responsible. — *Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.*

Lever Switch

New "0-42" Lever Switch is primarily designed for use in aircraft, radio, communication, alarm systems, testing apparatus and a wide range of industrial applications. It is available in an



almost unlimited series of combinations of contact assemblies. Contacts, pile-ups and lever action assembled to meet specific requirement. Design and materials are said to combine ruggedness and light weight: the unit with eight contact springs weighs only 4½ oz. Switch has positive action—locking, non-locking (spring return to neutral position) and no throw stops. Said to be a feature not found in other lever switches is the large well-formed handle which permits firm grip by a gloved hand. Rating—maximum recommended, 5 amperes, 110-volt a.c., (non-inductive).—*Donald P. Mossman, Inc., 6133 N. Northwest Highway, Chicago, Ill.*

One glance inside the case of a Frahm Tachometer shows its striking simplicity. The sole mechanism is a set of accurately tuned steel reeds which pick up the minute vibratory impulses of the machine which the instrument need merely touch, and the R.P.M. is indicated on the scale by a sympathetically vibrating reed. Because *no contact with the rotating element is required,* these instruments solve troublesome problems of indicating speed . . . without belts, gears, flexible shafts or electrical connections.

This principle and the method of indication are unique among speed measuring instruments. The Frahm Resonant-Reed Tachometer is as accurate as it is simple, with no parts to wear, adjust, lubricate or renew. It can be used in any position and will give years of trouble-free service. Built in types for permanent mounting . . . and for hand use in servicing, installation and maintenance work. Various ranges available from 900 to 30,000 R.P.M.

For a complete description of Frahm Tachometers together with lists of types and ranges commonly supplied, write for Bulletin 1590I.

JAMES G. BIDDLE CO. • 1211-13 ARCH STREET PHILADELPHIA, PENNA.

Now serving on

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★ In aircraft plants, engine shops, powder works, ballistic laboratories, radio, electrical and other plants; in research laboratories and engineering departments shaping the weapons and tools of today and tomorrow; on the fighting fronts afloat and ashore—yes, in every phase of this great Battle for Democracy, DuMont Cathode-Ray Oscillographs are in the service.

For the most part, standard type DuMont Oscillographs are employed. An adequate selection of standard types meets the wide range of requirements. But for the highly specialized needs arising out of the drastic industrial and military demands of the war, special models are constantly being developed and built. Regardless of the need, a DuMont Cathode-Ray Oscillograph or related instrument, is available.

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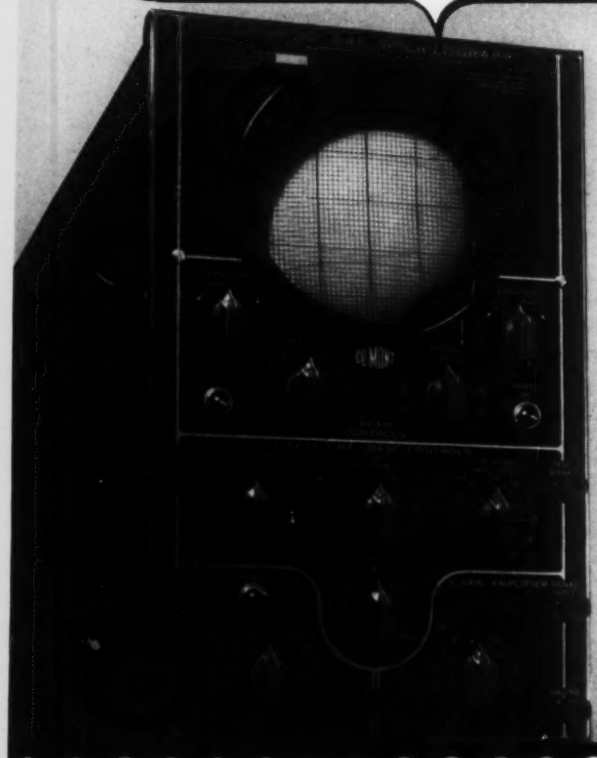

Wide selection of DuMont Oscillograph models—3" to 20".

DuMont Electronic Switch for placing two simultaneous signals on single tube screen.

DuMont Low-Frequency Linear-Time-Base Generator, providing sweeps as low as 1 cycle every few seconds.

Type 224 Oscillograph, with frequency response up to 2,000,000 cycles per second.

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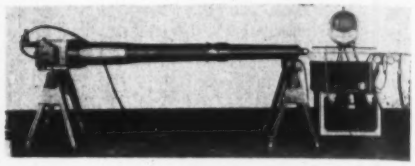
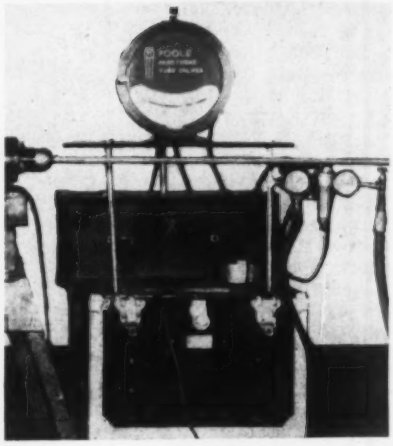
Indicating or Recording Gage for Bore Diameters

Original model of "Remotomike" has been manufactured for several years to give continuous indication from end to end of the inside diameters of refinery still tubes. At suggestion of Ordnance Department it has been modified to give a continuous indication or record of gun tube land and rifle groove diameters; it can be used to measure tapered powder chamber diameters. For ordnance work, several exclusive advantages are said to be obtained: (1) A new inspector obtains the same reading as a long-experienced star-gage operator because regulated air





pressure determines pressure of contact of feeler balls against tube wall; (2) A continuous and more complete picture of the inside gun tube surface is obtained because transmitter, when pushed through tube, gives a continuous indication of the progressive diameters; (3) No guides are necessary to keep it concentric and its measurement consistent." The Remotomike has been built in ranges of 0.050", 0.100", 0.150" and 0.200"; multiple-step ranges of as much as 1.175" with graduations of 0.001" are also available. Guns as small as 20 m/m and as large as 18" can be measured. Sensitivity is ±0.2% of scale range. Accuracy is within 0.5% of scale range. Three styles of receiver instruments are optienal: (A) Concentric-scale dial graduated in 0.0005" (each division 0.141" wide) for a range of 0.100". (B) Eccentric-scale dial graduated in 0.001" (each division 0.079" wide) for a range of 0.100". (C) Recorder, graduated in 0.001" (each division approx. 0.050" wide) for a range of 0.100". For the three-point measurement method, three steel balls protrude 120° apart through transmitter-housing cylindrical surface; serve as feelers to locate high or low spots; move radially in and out, independently. This radial movement of feeler balls is transmitted to measuring cone by a series of steel balls arranged radially in feeler ball guide housings. (For 2-pt. measurement, two steel balls

protrude 180° apart through transmitter-housing cylindrical surface; in addition, four auxiliary balls are located inside of transmitter-housing; these auxiliary balls serve to keep the measuring cone longitudinal axis in the plane of the feeler balls). The measuring cone—which is floating within the inner ball circle—is free to move laterally when one ball protrudes more than the others. It is positioned longitudinally by the action of a table against the thrust bearing in rear face of measuring cone, pushing it against the radial ball train assemblies. The lateral position of the cone is unfixed—it floats. A regulated air pressure is impressed on the cone table which in turn pushes the measuring cone against feeler ball trains. A soft-iron armature is linked with the measuring cone table; it moves in phase with the measuring cone's longitudinal travel. Balanced inductance bridge telemetering principle transmits motion of cone to the pointer on the receiver dial. Floating action of measuring cone makes transmitter independent of its position in tube or cylinder; the same indication is obtained whether transmitter is on bottom of tube or concentric with it. Inconsistency of "human feel" is eliminated; previous diameter readings can be duplicated.—*Poole Mfg. Engineers, 1705 N. Field St., Dallas, Texas.*

High-speed Relay for Generator Protection

New "Type CFD" generator differential relay, for use in generator protection, is a high-speed induction-cylinder device utilizing new "product restraint" principle with variable slope characteristics (described by A. J. McConnell of the Company's Central Station Department at the AIEE national technical meeting on January 25). New combination eliminates previously-encountered difficulty due to transient current transformer errors on heavy through faults. Use of "product restraint" principle assures positive operation on internal faults since the restraining force in case of any single-end-feed condition will be zero or negative because one of the two terms making up the product is zero. Relay is $20\frac{5}{16}$" by $5\frac{1}{2}$" in the standard 3-element drawout case, and can be supplied for surface or semi-flush mounting. Each element of the relay is of the familiar eight-pole, induction-cylinder type. Three poles are used for the differential operating function, and three poles provide the "product restraint."—*General Electric Co., Schenectady, N. Y.*

Accurate

COLD TESTS *and* HEAT TESTS

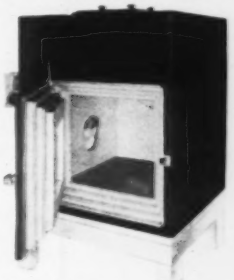
FOR PRECISION INSTRUMENTS

With Amcoil Test Chambers you can make accurate automatic tests of delicate instruments under the conditions they must face in actual performance. The same all-steel cabinet that tests for low temperature by mechanical refrigeration can create tropical heat electrically and with thermostatic control. Five thicknesses of glass hermetically sealed within the door afford perfect visibility of instruments under test.

A simple flip of the switch can effect the change from high temperature to sub zero temperature testing. This temperature change can be rapid or controlled to meet your test requirements. The Amcoil RTC-1A has a range of temperature from −70° C. to +70° C. (−95° F. to+160°F.).

American Coils offers a complete line of test chambers including dry ice models. Special Amcoil cabinets for altitude and humidity testing are available to widen the field of "war conditioning" for precision instruments.

Write for information on the types in which you're interested as well as further details on the models shown here. Amcoil engineers are available for advice and recommendations based on your specific needs.



M50TC-1A Interior 21"w.x21"h.x28"d. | **M50TC-2A** Interior 25"w.x28"h.x28"d.
Range: — 67°F. to + 160°F.
Dry Ice • Automatic Control

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AEROPOINT PERMIUM PIVOTS for instruments are the most outstanding improvement in years. They assure dependable, precise, snap action electro-mechanical energy transformation. Alloy tips are lubricious, non-blunting, corrosion proof, smooth, dense, tough—with herculean resistance to wear and vibration abuse. No increase in friction with use. Reduces field service replacement and maintenance. Instruments will remain more accurate longer. *Insist on AEROPOINTS for the "heartbeat" of better instruments.*

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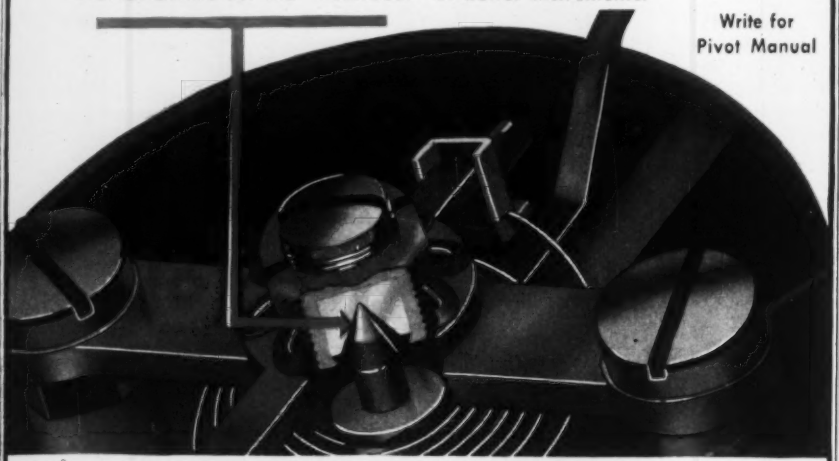

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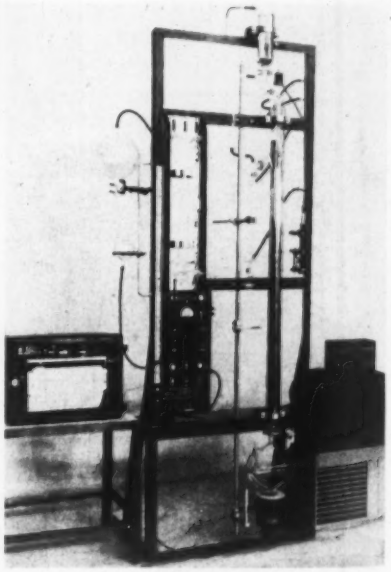
"Only AEROPOINT pivots > > > > > > > > > > > are made with PERMIUM"

High-temperature Fractionating Apparatus

Said to be an important addition to maker's line of fractionating equipment, new "Hyper-Cal" high-temperature (100 plates) high-efficiency fractional distillation apparatus has a reflux temperature operating range of –40°C. to 300°C. It is said to be a highly efficient apparatus for accurate fractionation of above room temperature of motor fuels. It incorporates latest developments in fractionating apparatus principles and constructions to take full advantage of the extreme fractionating efficiency, wide temperature range, and versatility of the also entirely new "Heli-Grid" packed "Hyper-Cal" distilling columns. It is recommended for a variety of research and control laboratory applications, including "super-fractionation" of motor fuels, cracked C-5 and heavier fractions, styrene mixtures, creosote and anthracene oils, essential oils and other distillable products. The "Hyper-Cal" apparatus framework and supports include a floor stand, adequate space for

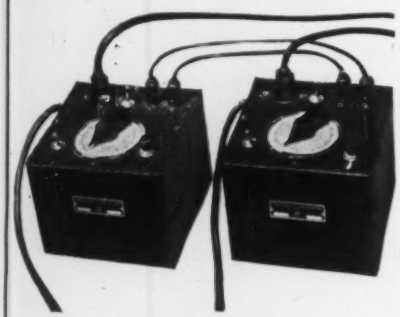


even a 12-liter distilling flask, convenient location of all parts for operating convenience. An absolute type vacuum control is included similar to that previously used (*J.I.E.C. Anal. Ed.* Vol. 5, p. 135, 1933) but simplified and improved including a 3-1 amplification McLeod gage, (graduated directly from 0 to 120 mm. abs.) An optional vapor compression type reflux refrigerating unit, using ethylene glycol is circulating fluid through reflux condenser, makes possible the cooling of reflux (and of jacketed distillate receiving buret) as low as –40°C. By the use of dry ice-acetone in the vapor condensing trap, even lower boiling gases can be condensed when necessary to minimize loss of vapors through vent line. The "Hyper-Cal" column is completely enclosed in a vacuum jacket including vacuum jacket top, bottom and side ground glass joints. Multiple metal radiation shields within the vacuum space provide for insulating effectiveness so high that even with 300°C. in the column, it is hardly possible to determine by touch whether the column is in oper-

PHOTOVOLT ELECTRONIC TIMER

An adjustable timing relay operating without clockwork or motor.

- High speed timing, from 1/20 sec. up.
- Immediate automatic resetting
- Push button and remote control



Any number of standard units can be combined for

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in continuous operation.

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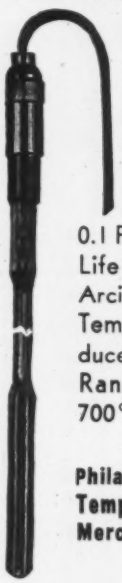

Mercury to Mercury Contacts : Increased Contact Capacity : Sensitivity within 0.1 F. Exceptionally Long Life and Stability : No Arcing : No Oxidation : Temperature Lag Reduced : Temperature Ranges adjustable to 700°F.

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•

The Philadelphia Thermometer Co.

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WRITE FOR CATALOGUE No. 104.

Oldest Thermometer Manufacturer in Philadelphia

ation only about 15 watts maximum compensating heat need be supplied to the specified compensating heater well. —*Pelniak Centrifugal Super-Contactor Co., 8312 S. Chicago Ave., Chicago, Ill.*

Metal Wear Gage

New McKee Wear Gage is for measuring the amount removed from metallic surfaces subjected to wear, abrasion, grinding, honing, lapping, etc. (as in cylinders and pistons, shafts and bearings, push rods, gears, etc.) Maximum amount of wear measurable is 0.0014". Minimum detectable wear (sensitivity) is 15 millionths of an inch. Measurements can be made: (1) on inside surfaces of cylinders down to 2 7/32" diam.; (2) on flat surfaces; (3) on outer surfaces of cylinders down to 1/32" diam.; (4) on spheres down to 1/4" diam. On inside of a cylinder, measurements can be made at any distance up to 10" from the end; also on any accessible spot on outer surface of flats, cylinders, or spheres. *Principle:* A diamond-shaped pyramidal indentation is made in the surface. Depth of indentation is a function of peak angle of indenter point. Measurement of initial length of base of indentation gives initial depth. As wear takes place, entire diamond-shaped indentation becomes smaller (shorter). After wear has taken place, a second measurement of indentation shows amount of material removed from test surface. For gages, etc., where it is desirable to know when a predetermined amount of wear has taken place, a mark of the desired depth is placed on the wearing surface. When this mark disappears, the permissible amount of wear has taken place. Another method is to place a series of marks, each of different but known depth, on the wearing surface. Advantage of new method is that it provides an indication of wear only, while usual measurements of changes in dimensions do not distinguish local wear or differentiate between wear and distortion. McKee Wear Gage consists of: (1) indenter; (2) measuring microscope; (3) cylinder indentation locater; (4) polishing template. Each instrument is supplied with a multiplying factor for converting microscope readings to indentation depth on flat, also a correction formula and table for curved surfaces, also information regarding a further correction for elasticity or hardness of the particular material tested. — *American Instrument Co., Silver Spring, Maryland.*

Introducing

The TYPE I
MICRO-MANOMETER

THE NEWEST OF OUR PRECISION INSTRUMENTS

A MICRO-PRECISION MANOMETER for measuring exceedingly small pressure differentials.

This was built by us to conform to drawings and specifications provided by a customer whose specific application was for the measurement of the very low pressures encountered in the development of superchargers.

The principle of operation is a movable manometer well that can be adjusted in a vertical direction by means of a lead-screw. The position of the lead-screw is indicated by a counter reading in thousandths of an inch.

The manometer level is shown in a straight glass tube mounted on a translucent disc which can be rotated to change the position of the tube from an inclination of 30° to horizontal with a corresponding increase in sensitivity.

A lamp behind the translucent disc permits the meniscus to be read under all lighting conditions.

THE TYPE I MICRO-MANOMETER has a pressure range of ten inches of water for either vacuum or pressure. It is 8" wide, 18" high, and 11" deep, and is operated by 120-volt AC or DC.

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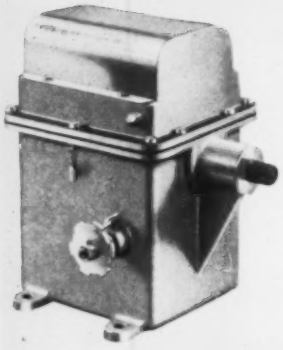
BARBER-COLMAN POWER UNITS



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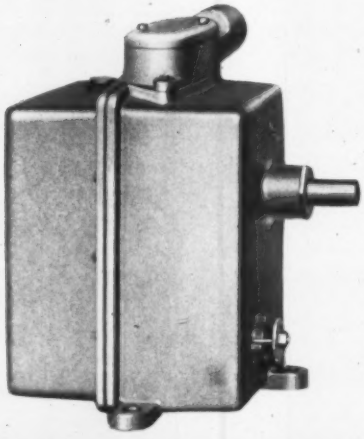
When you need a compact, powerful, motor-driven unit for positive or proportional positioning service, a Barber-Colman Power Unit may be just what you are looking for. Controllable by manual switch, thermostat, standard recording instrument, or Microtherm. Write for data bulletin F-1912 and have the facts at hand.



MAXIMUM SERVICE Controls BARBER-COLMAN COMPANY MINIMUM MAINTENANCE

UNITS SHOWN...

Above is a multi-position type with either fixed or adjustable speed. At the right is a heavy-duty type for handling large valves, blast gates, fuel carburetors, etc. Both these models have oil-submerged motors for long life.

BARBER-COLMAN COMPANY 1202 ROCK STREET ROCKFORD, ILLINOIS

Test Insulation the Modern Way with a MODEL B-5

MEGOHMER

NEW BATTERY-VIBRATOR TYPE

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VARIOUS NEW MODELS AND RANGES

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WRITE FOR BULLETIN No. 430

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for 1/200 to 2 amps.

All delicate meters.
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Testers
Radio Rectifier
Tubes
Thermocouples, etc.

Locked Cap Assembly, anti-vibration twist at 90°, and non-crystalling fuse element, are exclusive Littelfuse features. Panel and fuse protection engineered to requirements.

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Slo-Blo-Littelfuses
1/100 to 1 amp, with high time lag.

For
Control Circuits
Small Coils
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Interrupters
Vibrators Solenoids
Small motors, etc.

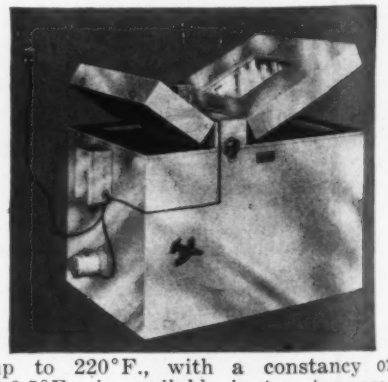
Circuit-testing By-pass

New circuit-testing device for Novalux loop-sectionalizing cutouts equipped with a Thyrite by-pass is announced. This testing by-pass is equipped with

an SL-type film cutout (shown being inserted) which provides a quick and inexpensive means of testing circuits—to determine whether a circuit is actually closed before installing a new Thyrite by-pass. If an open circuit causes the cutout to trip out, circuit is repaired and testing by-pass is inserted before Thyrite by-pass is put into place. New circuit-testing by-pass is not intended as a substitute for Thyrite by-pass because, unlike Thyrite device, film cut out is unable to differentiate between a surge voltage such as that caused by lightning and a sustained overvoltage caused by an open circuit.—*Lighting Div., General Electric Co., Schenectady, N. Y.*

Constant-temperature Dry-ice Cabinet

Intended for use where expensive mechanical refrigeration would not be justified, new "Aminco Dry-ice Cabinet" provides temperatures from –90°F.

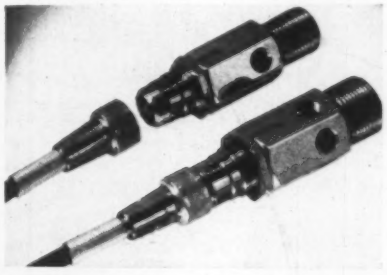


up to 220°F., with a constancy of ±0.5°F.; is available in two temperature ranges: from zero to –90°F., and from 220°F. to –90°F. Temperatures of –65°F. and –90°F. are attained in 15 and 30 minutes respectively from an initial temperature of 85°F. Temperatures can be held at –40°F. and –90°F. in an ambient temperature of 85°F. for 24 hours with 40 and 60 lbs. of dry ice respectively. Cabinet is portable and ready for operation after packing with dry ice and plugging cord into current supply. Once packed with dry ice it requires no further attention until a new charge of dry ice is required. In the low-temperature model, ±0.5° temperature constancy is made possible by means of an "Aminco Quickset Bimetal Thermoregulator" which, through a solenoid and time-delay relay, oper-

ates a damper that allows air to be passed over the dry ice when cooling is needed, or to be by-passed when cooling is not needed. Temperature control system requires only natural heat leakage for its operation. No electric heaters are used in this model to control the temperature. In the high-and-low temperature model, control described above is augmented by "Aminco LoLag Electric Heaters" operated through an "Aminco Silent Power Relay." Working chamber (24" cube) has a hinged removable cover in which is incorporated a 5-ply vacuum-sealed plate glass window. Another hinged cover gives access to 75-lb.-capacity dry-ice compartment which is heavily insulated from working chamber and by-pass duct, thus conserving dry ice when refrigeration is not required. Air circulation is by means of a fan driven by a motor mounted outside cabinet. An externally-controlled hand damper limits amount of air passed over dry ice in proportion to the temperature desired. — *American Instrument Co., Silver Spring, Md.*

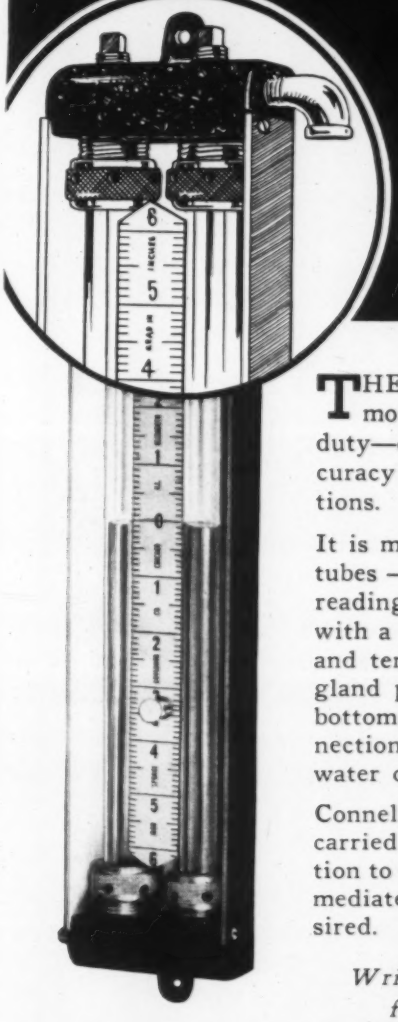
Pressure and Detonation Pickups

In newly-announced pressure and detonation pickups for use in testing engines, pumps, compressors, etc., the deflections of a pressure-responsive diaphragm produce magnetic flux variations in a coil assembly and hence an output voltage representing the varying pressures. Two types are available: "Model No. 3000" fits into a hole tapped to receive a ⅞"-18 thread. "No. 3000A" fits into standard aircraft engine 18-mm. spark plug hole. Output voltages as high as 40 millivolts are obtainable from these pickups when used with standard C.F.R. gasoline testing engine using 70 octane rating gasoline, this voltage being total of detonation and regular explosion. Should detonation or any cyclic engine pressure voltage be required, "Electro Filter Model No. 2300" can be used to select these voltages over a range of 2,000 to 8,000 cycles. Pickups withstand temperatures met with in gas engines by reason of high-temperature insulation over windings, also proper ventilation. No binding posts: socket attached to a shielded 7-ft. cable is screwed to end of pickup, thereby making a completely shielded connection to pickup terminals. Complete electrical shielding of the pickup and cable eliminates ignition and other undesired electrical interference. Two types of diaphragms are furnished with each pickup, one for ordinary pressures met with in gas engines and compressors; the other for high-compression aviation engines.—*Electro Products Labs., 549 W. Randolph St., Chicago, Ill.*



Connelly EXTRA HEAVY DUTY Manometers

FOR PERMANENT MOUNTING



THE New Connelly Manometer, model 3400—built for extra heavy duty—can be depended upon for accuracy and long life under all conditions.

It is made with large bore, clear glass tubes — ¾" in diameter — for easier reading even at a distance. Supplied with a scale graduated either in inches and tenths or in metric measure. It is gland packed, with drain plugs at the bottom and is fitted for ⅛" pipe connections. Made for use with either water or special anti-freeze solution.

Connelly Model 3400 Manometers are carried in stock in five sizes. In addition to these stock sizes, larger or intermediate sizes can be supplied if desired.

Write today for bulletin giving further details and prices.

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CHICAGO, ILL. – ELIZABETH N. J.

ALUMINIZED FRONT SURFACE MIRRORS

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AFTER THE STORM!

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Every PALMER Thermometer is finding its place in the network of equipment needed to back the boys at war because:

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(Catalog No. 300-D sent promptly)

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Gage Blocks

New standard "Set 400" of "Doall Master Gage Blocks" consists of 81 blocks, ranging from 0.050" to 4.00". Available in grades "AA," "A" and "B" (accuracies 2, 4 and 8 millionths of an inch), all blocks have measuring

surfaces lapped to a flatness of less than a quarter-wavelength of light and to a mirror finish. Thus, blocks can be wrung together in combinations enabling user to secure practically any dimension in steps of 0.0001" from 0.1000" to 12.00". Illustration of an inspector checking a 4" micrometer shows also the mahogany case supplied. Announcement lays stress on fact that the precision optical measuring instruments which are used in maker's air-conditioned laboratory to check the blocks produced are available also to users for rechecking their gage blocks after use: used gage blocks will be recalibrated and those worn beyond tolerance of the original set replaced to restore the original grade of accuracy of the complete set.—*Savage Tool Co., Savage, Minn.*

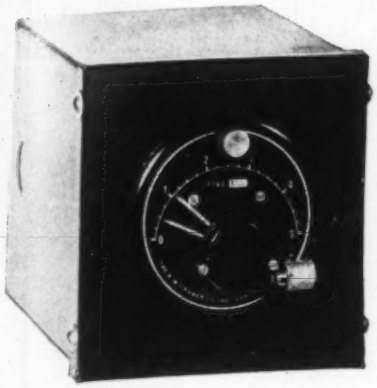
Manual-reset Cycle-repeat Automatic Timers

New "RS4" and "RS5" synchronous-motor-driven timers, of the manual reset type, are available in time ranges up to 5 hours (longer if desired) for

RS4-M5

timing electrical circuits. Applications include automatic timing of machinery operations, chemical and food processing, heating processes, etc. These timers repeat their time cycle upon manual operation of a built-in start button. They indicate at a glance the expired and unexpired times as well as the setting time. RS4 timer has a double-throw

switch and opens or closes the circuit, depending upon the choice of circuit, and resets by pressing and then releasing the start button, which also resets the timer. RS5 differs in that it is mechanically held in a neutral position when button is depressed, and starts timing cycle by pulling the start button outwardly. These timers operate an s-p.d.t. switch with a capacity of 10

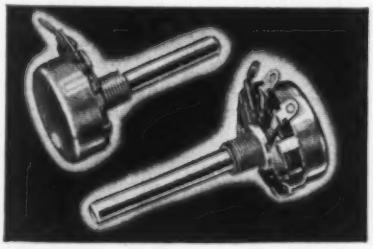


RS5-M5

amperes at 115 volts or 5 amperes at 220 volts a.c. non inductive load, and will control a ⅓ h.p. motor load, a heater load up to 1200 watts, a lamp load up to 250 watts or a relay load which does not exceed 15 amperes inrush at 115 volts a.c. Both are housed in black Bakelite case designed for flush panel mounting. Dimensions, 3¼" diam. and about 4½" length overall. They can also be supplied in dust- or moisture-proof surface-mounting steel housings, as well as in explosion-proof cases, arranged for conduit connections, and also with built-in visual or audible signals. —*The R. W. Cramer Co., Inc., Centerbrook, Conn.*

Sealed Variable Resistors

Said to meet today's demands for units which will perform correctly under intensely humid or dusty conditions, and in either standard radio or high-



frequency equipment, two new closed-cover sealed variable resistors are announced: (1) new "Type MG" is designed for use under extreme conditions. A leakage resistance of the order of 300 megohms after 48 hours in 95% humidity at 40°C. is obtained in this new design. Spacing of current-carrying parts is greater, and surface insulation of molded base is several times that of previous laminated-base units. (2) "Type LP" is now furnished with a dust-proof cover and is so sealed that resistivity from current-carrying parts after 48 hours in 95% humidity at 40°C. is five times that of the previous open construction units. — *Stackpole Carbon Co., St. Marys, Pa.*

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The Arnold Engineering Company produces all **ALNICO** types including **ALNICO V.**

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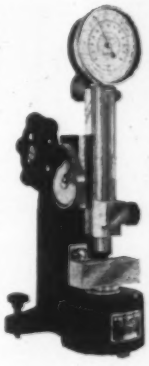

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Bulletin 504
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Portable Standard with single electrical zero return.

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NEW YORK TRANSFORMER COMPANY

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Dynamometer Scales

Announcement is made of availability of dynamometers embodying maker's standard dial scale with certain modifications, in conjunction with energy-absorption mechanisms of several standard makes. Fig. 1 shows a dynamometer arrangement comprising a scale and a Westinghouse energy-absorption

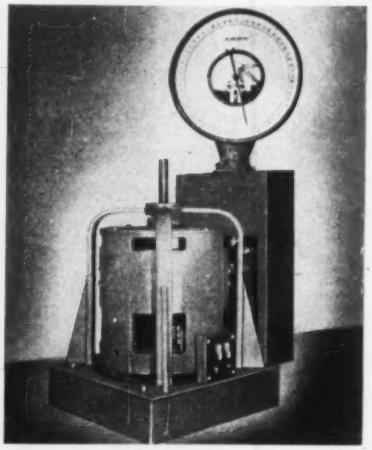


Fig. 1

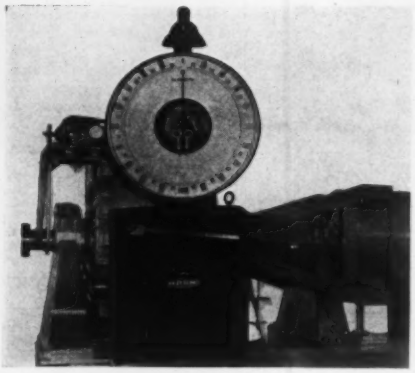
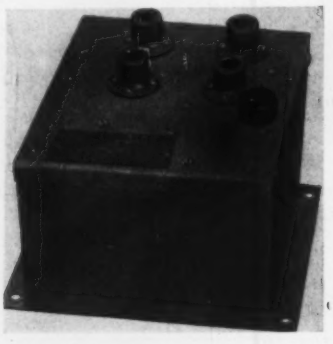


Fig. 2

system, designed for testing vertical steam turbines. Fig. 2 shows the Packard dynamometer arrangement for determining brake-horsepower of engines of more than 2000 hp. for ships, planes and tanks.—*The Kron Co., Bridgeport, Conn.*

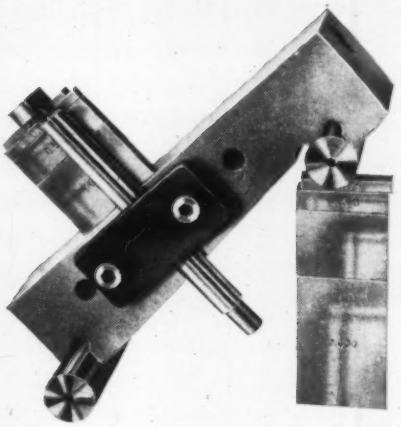
Aircraft Instrument F.L. Inverter Ballast

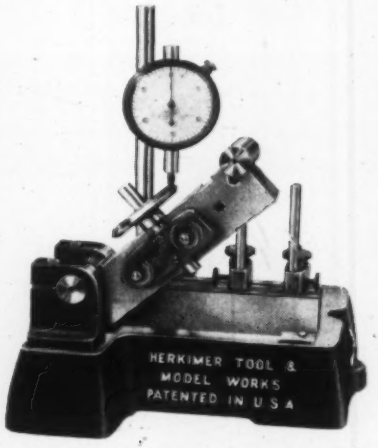
New d-c. to a-c. inverter ballast for fluorescent lighting of aircraft instruments provides output voltage suitable for the operation of two 4-watt Mazda F lamps, designated as T-6 by 2½, FA-5 (pinless) blue F-6 lamp, for instrument-panel lighting. They also provide, by means of a second winding, a 3-volt, 1.5 amp. output supply for operation of such lamps as the 0.19-amp. 3-volt T-1¼ lamps for indicator lights. New ballast is suitable for operation at rated currents at altitudes from sea level to 35,000 ft.; weighs 2½ lbs. Windings are treated with "a special compound" that allows operation at ambient temperatures from −15°F. to 140°F. without damage to coils.—*General Electric Co., Schenectady, N. Y.*

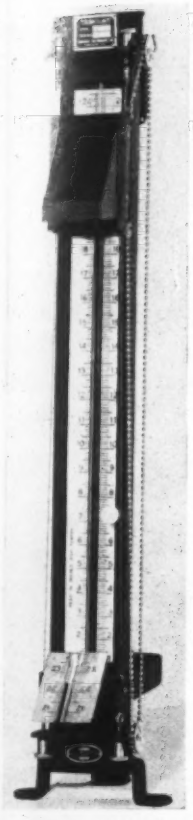


Sine Bars for Bevel Gear Gaging

Special Sine Bars for bevel gear gaging are said to reduce the gaging of bevel gears to its simplest form. "Heretofore," states announcement, "the method of setting up to manufacture and the method of checking precise bevel gears, or blanks for precise bevel gears, have required complicated measuring methods involving difficult computations and manipulations. Even then, recourse to trial and error was necessary." From illustrations it will be noted that the sine bar is provided with an aligning seat which will receive and will align either a special apex-defining setting-up bar, or a mandrel on which the gear blank to be measured may be mounted. Set-up bar is used in conjunction with suitable measuring devices (or preferably with







NEW!

TRIMOUNT PERISCOPE MANOMETER

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The Trimount periscope device makes possible accurate, easy reading on manometers of such height as to be otherwise difficult to read. Fully equipped with a 6 volt electric light and transformer for 110 volt circuits.

This is typical of the broad range of manometers available at Trimount to meet any and all requirements.

Write today for the illustrated Trimount Manometer Bulletin.

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TRIMOUNT INSTRUMENT CO.

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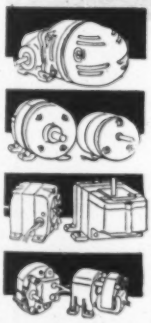
Fractional H. P. Electrical Motors in War Quantities



Dependable motors for A.C., D.C., or Universal operation, from 1/3000 to 1/3 horsepower, with speeds of from 3000 RPM to 25,000 RPM, and with almost any geared speed desired with worm or spur gearing. Light in weight and compact. More than 26 standard and innumerable special types.

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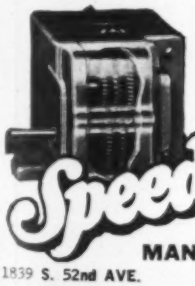
SpeedWay will make motors *and units incorporating motors* to YOUR specifications and/or Army, Navy or Air Corps specifications.

Whether or not they can supply your needs, SpeedWay will give you prompt, courteous service. Send details and specifications for quotations or requirements for recommendations of the SpeedWay Technical Staff.



SpeedWay

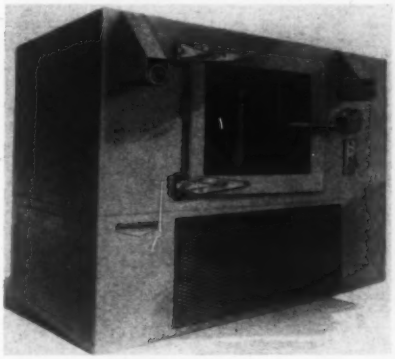
MANUFACTURING CO.

1839 S. 52nd AVE. CICERO, ILLINOIS

gage blocks) to define a plane passing through apex of gear cone of bevel gear as related to thrust face of gear hub. The set-up can be made from dimensions usually given on drawings for bevel gears and a direct reading with a dial indicator can be taken. No involved calculations being involved, this gaging may be performed by anyone having knowledge of blueprint reading and ordinary gaging practice, it is said. With set-up completed it is possible to perform the following gaging functions: (1) Check dimensional accuracy of addendum cone (gear face) as related to thrust face of hub. (2) Check accuracy of cone angle. (3) Check run-out of gear face. *Two models:* one for use on a conventional surface plate; the other a self-contained unit with its own base, set-up anvil, gage rod holders, etc.—*Herkimer Tool & Model Works, Herkimer, N. Y.*

High- and Low-temperature Testing Cabinet

For temperature tests of instruments and materials, new "Hi-Low" machine (basic "Model 3600HL" illustrated) is available in three temperature ranges: from –60°F. to +170°F.; –80°F. to +170°F., and –90°F. to +170°F. In



"Model 3600HL90," for example, a temperature drop from ambient of +80°F. to –60°F. can be accomplished in 45 minutes; to –70°F. in 1 hour; to –80°F. in 85 minutes, and to –90°F. in 140 minutes. Also, heating to +170°F. from –90°F. can be accomplished in 90 minutes; from –80°F. in 85 minutes, from –70°F. in 80 minutes, and from –60°F. in 75 minutes. Machine is entirely self-contained, requires only a source of electrical power. Outside dimensions: height 84″; depth 52″; length 94″. Net clear usable working space is 48″ × 36″ × 36″. Insulation is 8″ Fiberglass. For the "Hi" side, strip heaters are located in the air stream for defrosting and rapid heating; for the "Low" side, finned type coils are used. Condensing unit is a 4-, 7½- or 10-h.p. 2-stage air-cooled "Freon-12 or 22" machine as specified. Temperature recording and controlling instruments are provided to meet usage requirements. Door illustrated is standard; variations in size and location may be obtained as specified. Interior is lighted by two 40-watt Lumiline lamps, on sides of door. Operating switches are on front of cabinet. Special conduit openings, terminal panel and binding posts can be obtained as accessory equipment.—*Kold-Hold Mfg. Co., Lansing, Mich.*

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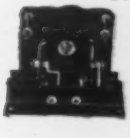

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counter, chronograph, etc., with clutches, relays and switches for simultaneous automatic operations which test engineers seldom can do by hand without possibility of mistakes.—*The Kron Co., Bridgeport, Conn.*

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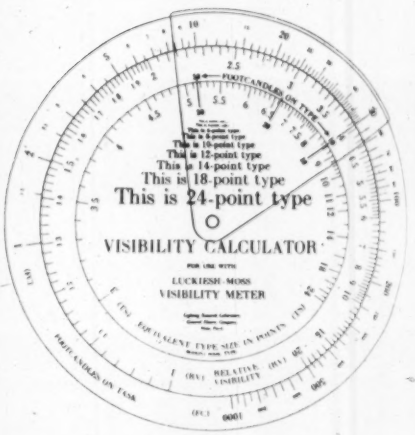
New "Visibility Calculator," designed for use with the Luckiesh-Moss Visibility Meter (see *Instruments*, Nov.



1935, page 305) permits rapid determination of relative visibility of any visual task when amounts of light on that

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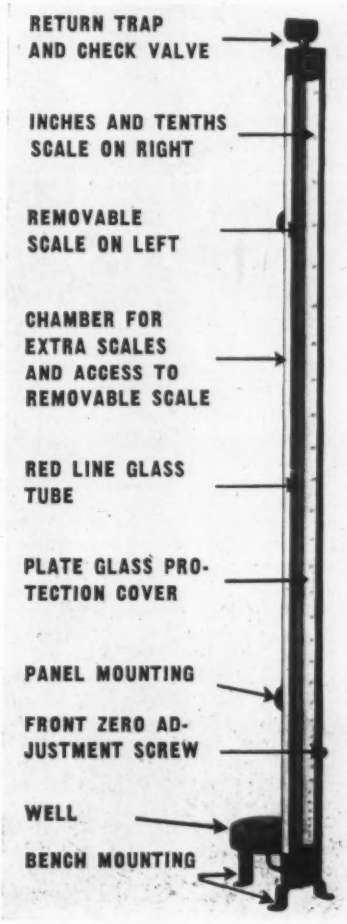
RETURN TRAP AND CHECK VALVE
INCHES AND TENTHS SCALE ON RIGHT
REMOVABLE SCALE ON LEFT
CHAMBER FOR EXTRA SCALES AND ACCESS TO REMOVABLE SCALE
RED LINE GLASS TUBE
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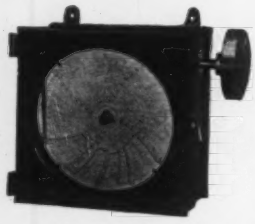

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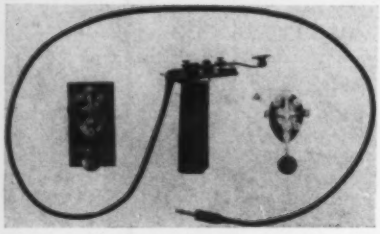

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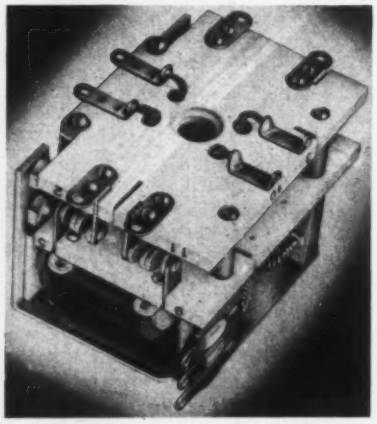
High-speed Aircraft Relay

New "Model AK" is a high-speed keying and break-in relay for aircraft radio equipment. It is designed for high voltage and resistance to vibration. Its push-pull magnetic arrangement provides magnetic holding pressure on both



transmit and receive contacts. One pole is equipped with two windings: one a holding winding connected directly across battery supply; the other connected in series with the single winding on the other pole and polarized so that when circuit is completed through key, flux is neutralized on the holding or receive position pole and armature pulls up to transmit position. Opening the key cuts off bucking flux and holding flux pulls armature back to receive position. New relay is completely balanced and its arms are equipped with anti-bounce features. It keys at twenty cycles; its contact rating is 1,000 volts at 30,000 feet, 20 megacycles; it is insulated to sustain 10,000 volts at sea level; withstands vibratory motion to better than 20 G. All terminals are easily accessible; insulation plate is of high-pressure steatite. Standard models for 12- and 24-volts d-c. circuits; wattage consumption is 5.5 in first position and 17.0 in second position; 4-pole double-throw. Dimension $2\frac{7}{16}$" x $3\frac{1}{2}$" x $2\frac{1}{4}$"; weight 17 oz.—*Allied Control Co., 227 Fulton St., New York City.*

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Ordnance Production Gaging

By CAPTAIN RUSH A. BOWMAN

In charge of Pittsburgh Gage Laboratory, Ordnance Department, U. S. Army

CHAPTER VIII

THREAD GAGING

Thread gaging represents the only field of measurement control which has been standardized nationally. As has been mentioned before, the National Bureau of Standards has set up in "Gage Blanks" (CS8-41) general specifications for a number of the commoner types of gage. It makes no mention, however, of the technical design of these gages with respect to relationship of gage tolerance to component tolerance, wear allowance, etc. The one field where there is such standardization is in the gaging of screw threads. This standardization had been in wide use for a number of years

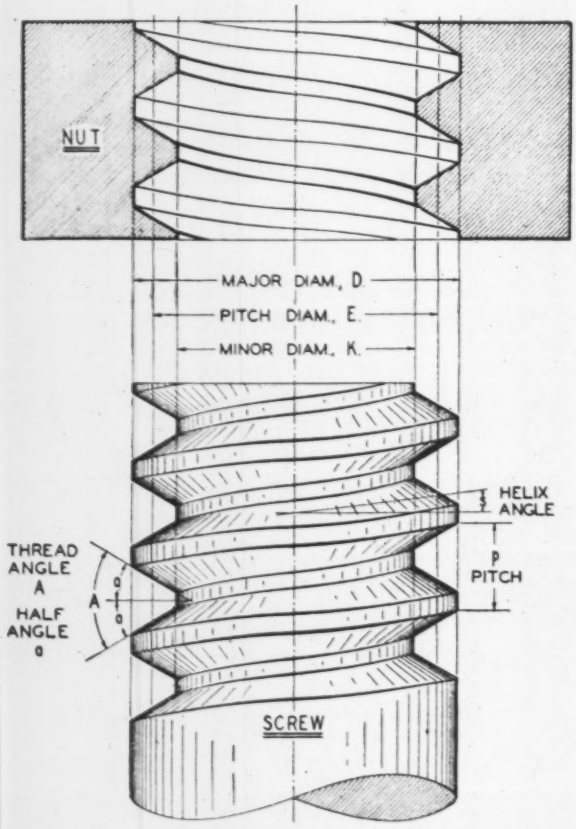


Fig. 1. Standard screw thread notation (From Handbook H28).

under the National Screw Thread Commission. From 1942 it is under the Interdepartmental Screw Thread Committee established by the War, Navy and Commerce Departments.

The book, "Screw-Thread Standards for Federal Services" (National Bureau of Standards Handbook H28) is the official document which sets the standards for screw threads. This 241-page book, published in 1942, is comprehensive, clear in its presentation and indispensable wherever thread gaging problems are likely to arise.

Definitions and Symbols

In the last few years there have been changes in terminology and notation. The 1942 edition of "Screw Thread Standards for Federal Services" devotes a 6-page section to definitions of terms and lists of symbols which, in all likelihood, will stand for many years to come because they are meant to do away with confusion. They should, therefore, be adhered to in order to prevent any confusion. Slight departures (such as "outside" instead of "external") which do not cause confusion need not be fought or curbed to the extent of refusing to use blueprints or specifications where these old terms are used; but in almost every other instance the use of non-standard terms and symbols is likely to cause needless delays and may cause mistakes. The following list has been made up from "Screw Thread Standards" for easy reference. Readers who memorize it will find that they will save themselves from frequently looking up the Standards handbook.

External thread—A thread on the outside of a member. Example: A threaded plug.

Internal thread—A thread on the inside of a member. Example: A threaded hole.

(These terms are defined because of possible confusion arising from the fact that an "internal member" has an "external thread," and vice versa. For the sake of brevity an external thread is referred to as a "screw" and an internal thread as a "nut.")

Major diameter—The largest diameter of the thread of the screw or nut. The term "major diameter" replaces the term "outside diameter" as applied to the thread of a screw and also the term "full diameter" as applied to the thread of a nut. . . . *D*

Corresponding radius . . . . . *d*

Minor diameter—The smallest diameter of the thread of the screw or nut. The term "minor diameter" replaces the term "core diameter" as applied to the thread of a screw and also the term "inside diameter" as applied to the thread of a nut. . . . . *K*

Corresponding radius . . . . . *k*

Pitch diameter—On a straight screw thread, the diameter of an imaginary cylinder, the surface of which would pass through the threads at such points as to make equal the width of the threads and the

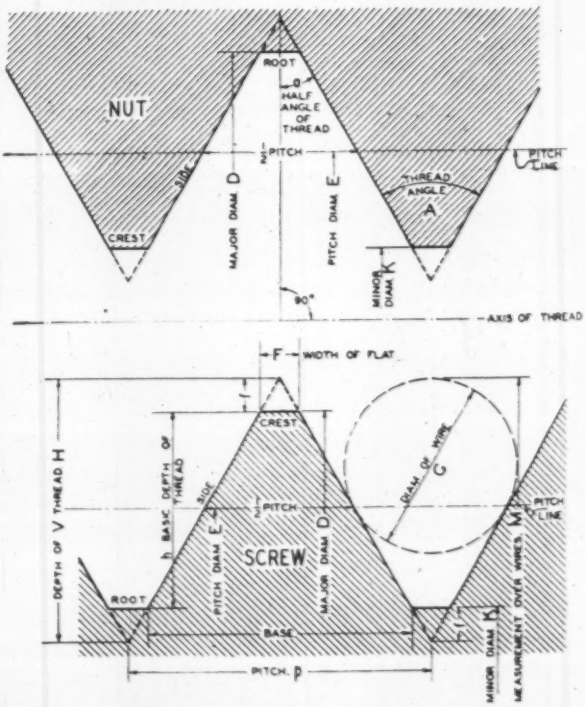


Fig. 2. Standard screw thread notation (From Handbook H28).

wi[illegible] the spaces cut by the surface of the cylinder[illegible] a taper screw thread, the diameter, at a giv[illegible]stance from a reference plane perpendicular to [illegible] axis of an imaginary cone, the surface of wh[illegible] would pass through the threads at such points as [illegible]make equal the width of the threads and the wid[illegible] of the spaces cut by the surface of the cone.) . E

[illegible]esponding radius . . . . . e

Pitch (or thread interval)—The distance from a point on a screw thread to a corresponding point on the next thread measured parallel to the axis. . $p = 1/n$

$$\text{Pitch in inches} = \frac{1}{\text{Number of threads per inch}}$$

Lead—The distance a screw thread advances axially in one turn. On a single-thread screw the lead and pitch are identical; on a double-thread screw the lead is twice the pitch; on a triple-thread screw the lead is three times the pitch, etc. . . . . $L = 1/N$

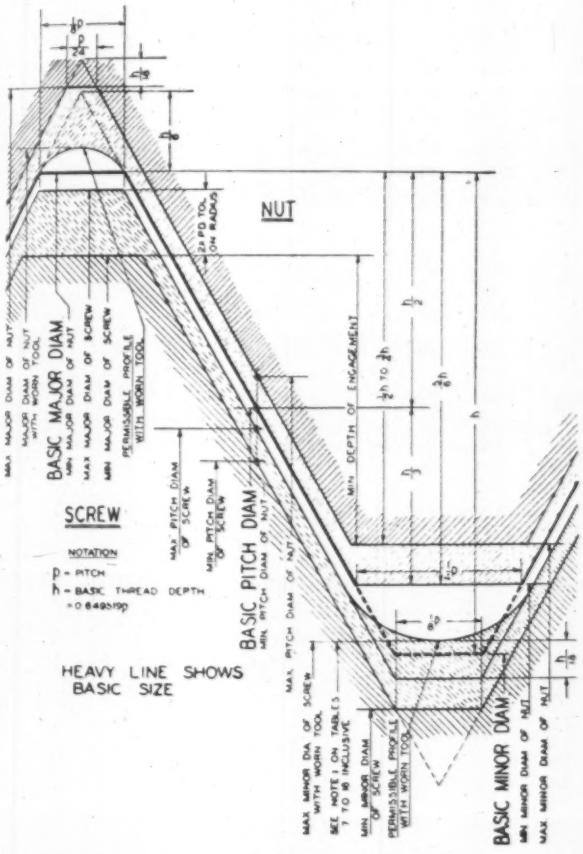


Fig. 3. Illustrating tolerances, allowance (neutral space) and crest clearances for class 1 fit (From Handbook H28).

Angle of thread—The angle included between the sides of the thread measured in an axial plane. A (alpha)

Half angle of thread—The angle included between a side of the thread and the normal to the axis, measured in an axial plane. . . . . a or a

Helix angle—the angle made by the helix, or conical spiral of the thread, at the pitch diameter with a plane perpendicular to the axis. . . . . s

Tangent of helix angle . . . . $S = L/(3.14159 \times E)$

Crest—The surface of the thread corresponding to the major diameter of the screw and the minor diameter of the nut.

Root—The surface of the thread corresponding to the minor diameter of the screw and the major diameter of the nut.

Side or flank—The surface of the thread which connects the crest with the root.

Axis of a screw—the longitudinal central line through the screw.

Base of thread—The bottom section of the thread; the greatest section between the two adjacent roots.

Depth of thread—The distance between the crest and the base of the thread measured normal to the axis.

Number of threads—Number of threads in 1 inch of length. . . . . n

Number of turns per inch . . . . . N

Length of engagement—The length of contact between two mated parts, measured axially. . . . . Q

Depth of engagement—The depth of thread contact of two mated parts, measured radially.

Pitch line—An element of the imaginary cylinder or cone specified in the definition of "Pitch diameter."

Thickness of thread—The distance between the adjacent sides of the thread measured along or parallel to the pitch line. . . . . t

Width of basic flat at top, crest, or root . . . . . F

Depth of basic truncation . . . . . f

Depth of sharp V thread . . . . . H

Basic depth or height of truncated thread . . . . h

Mean area—The term "mean area of a screw," when used in specifications and for other purposes, designates the cross-sectional area computed from the mean of the basic pitch and minor diameters.

Figs. 1 and 2 illustrate the use of the National Standard screw-thread terms and symbols. Fig. 3 also is useful in this regard and it specifically illustrates the tolerances, allowance and crest clearances for class 1 fit. (For illustrations of class 2, class 3 and class 4 fits, refer to Section III of "Screw-Thread Standards.")

Types of Thread Gages

Thread gages follow the same general classifications as ordinary inside and outside dimension gages. For internal threads, plug gages and pin gages are used. Indicating caliper and expanding types, however, are not used, as no

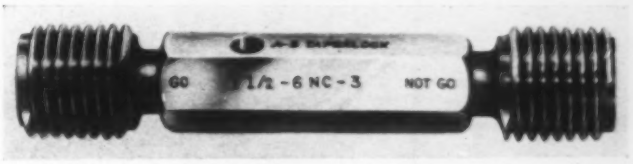


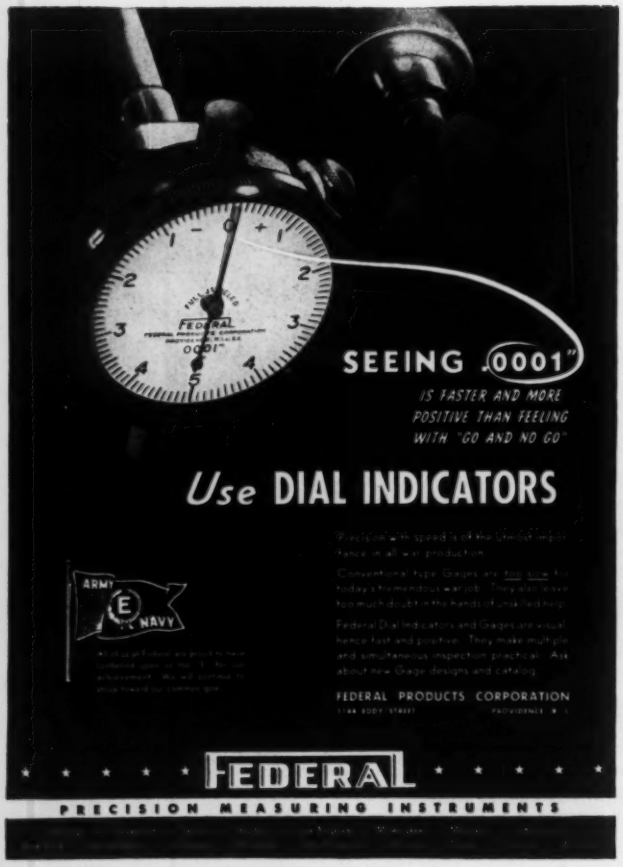
Fig. 4. Double-end thread plug gage for inspection of inside threads. This gage is made to American Gage design standards and in accordance with National Bureau of Standards Handbook H28

device has thus far been developed whereby the pitch diameter, lead, thread form, major and minor diameters may all be checked in one operation.

External threads are checked with ring gages and snap gages.

Figs. 4 to 9 show the different types with the exception of the pin type thread gage for internal threads. The pin type, however, resembles the setting gage shown in Fig. 7. When used as a pin gage, one head carrying the roll is movable on the shaft. This head carries a gaging point. Another gaging point is affixed to the shaft. A "go" and "not go" "feeler" block is provided in order that determination may be made that the part is within component tolerance.

Indicating type thread gages as shown in Fig. 9 have been developed for inspection of threads. Such a gage greatly increases the speed of inspection and has been found valuable in mass production. The part, which is shown in the figure, is placed in the gage in such a manner that the major diameter of the thread rests along the back rest and



the rolls engage the threads. The gage as shown in this figure does not, of course, check the lead of the thread and can be used only in measurement of pitch diameter.

Inspection of Thread Gages

Gages for Internal Threads

The pitch diameter of the plug and pin gages is measured by what is known as the three-wire method. Complete description of this method of inspection is found in the "Screw-Thread Standards for Federal Service," Appendix 2, together with an explanation of the theory of this method. Fig. 10 shows the inspection of the pitch diameter of a thread. In this particular case, a ball point on the instrument represents one wire, the other two wires being placed directly underneath the thread plug. Two things should be borne in mind when this type of inspection is made:

1. Since the thread wires are small, their temperature is raised rapidly by contact with the hand or any other part of the body (or even by the breath). Wires should, therefore, be handled with a chamois or with pliers having soft metal or wooden jaws. If a supermicrometer or comparator is used, the wires should be left in the inspection machine until they have assumed the same temperature as the part.

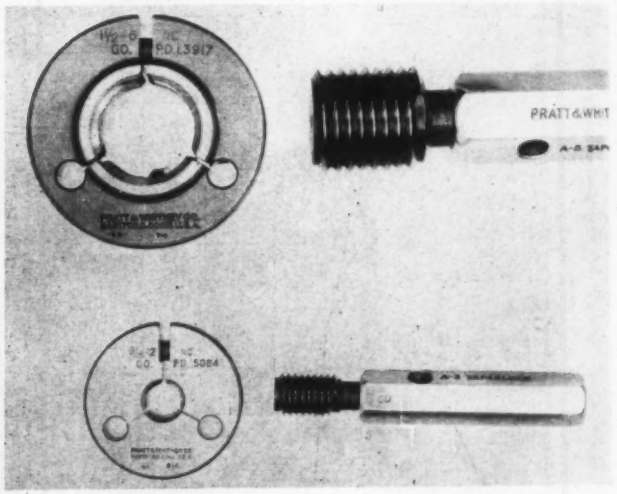


Fig. 5. Two types of thread rings with accompanying setting or check plugs. These rings are of the split type and are adjustable when worn by means of the adjusting nut, the cylinder of which may be seen in the top split.

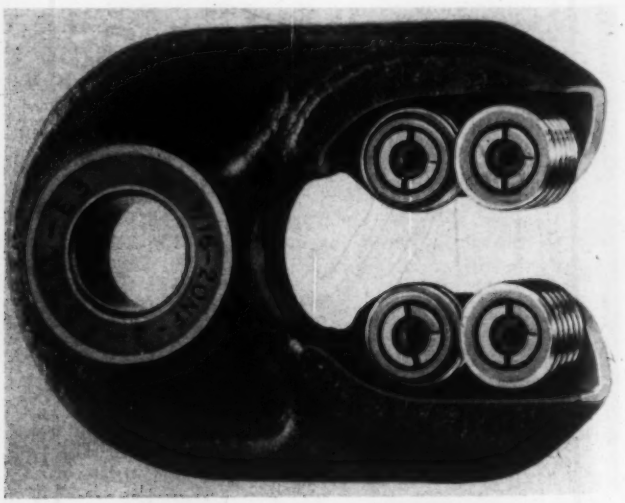


Fig. 6. Thread Snap Gage (roll type). These gages are set to setting plugs made to the same specifications as thread plug for setting of ring of the same size. Notice concentric adjusting screws in the rolls.

2. The formula

$$E = M + (\cot \alpha/2n) - G\,(1 + \csc \alpha)$$

which used in the case of a 60° thread reduces to

$$E = M + (0.86603/n) - 3G$$

which contains the term $3G$. Therefore, since G is the size of the wire, any error in wire size will be multiplied three times in the calculation of the pitch diameter. It is further very important that such wires be calibrated periodically. It is further of note that for this reason, the measurement of pitch diameter over wires is a more delicate measurement than the measurement of, for instance, a plain plug having the same tolerance.

The lead of the thread is measured either on an optical projector or comparator or with a machine designed specifically for that purpose.

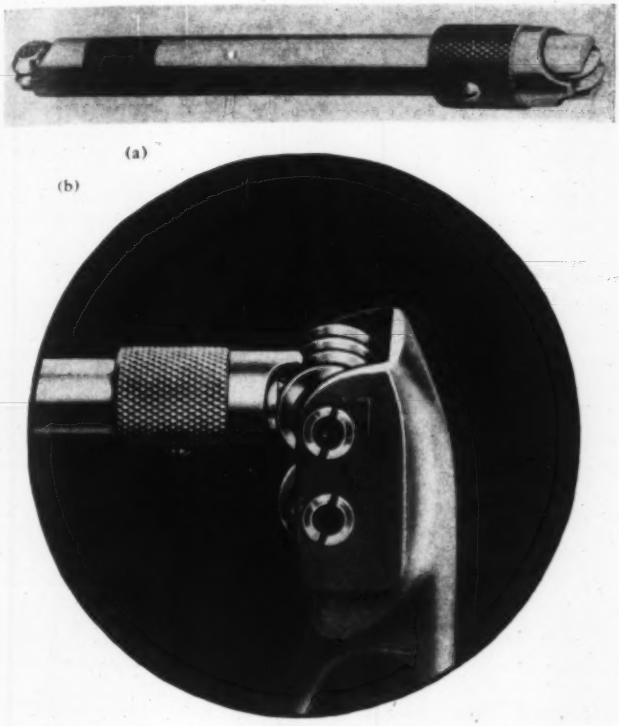


Fig. 7. (a) An adjusting bar used in setting of a thread snap gage. (b) One anvil of snap gage. The bar is used in lieu of an ordinary plug gage since it is adjustable and is not so expensive when the plug is extremely large and would have to be made of the annular type.

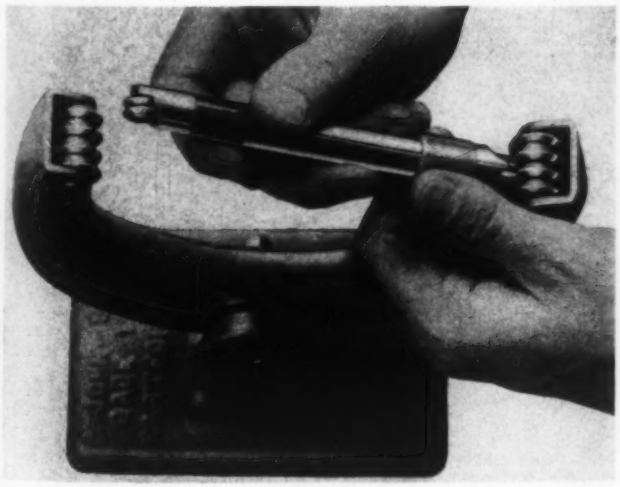


Fig. 8. A set bar being used in actual setting of a thread snap gage. "Feeling" and subsequent setting with a setting bar is somewhat more difficult than it would be with a plug gage.

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TABLE NO I

THREAD INSPECTION GAGES, DATA, ALLOWANCES, TOLERANCES.

THREADS PER INCH	PITCH	ROOT CLEAR P/4 NOT GO THREAD RINGS & PLUGS & ALL CHECKS	ROOT CLEAR P/8 GO THREAD RINGS & PLUGS. MAY BE SHARP V	LEAD ALLOWABLE VARIATION IN CLASS 1 2 3 ⊕	½ ANGLE TOL. ON CLASS 1 & 2 GO	½ ANGLE TOL. ON CLASS 3 GO & CLASS 1 2 3 NOT GO ⊕	PITCH DIAMETER. ALLOWANCE CLASS 1 & 2 GO	PITCH DIAMETER. ALLOWANCE CLASS 3 & 4 GO & ALL NOT GO	PITCH DIAMETER. TOLERANCE CLASS 1 & 2 GO	PITCH DIAMETER. TOLERANCE CLASS 3 GO & CLASS 1 2 3 NOT GO ⊕	MAJOR DIA THD PLUGS & MINOR DIA THD RINGS. CLEARANCE NOT GO ONLY	MAJOR DIA THD PLUGS & MINOR DIA THD RINGS. TOLERANCE GO & NOT GO
1	2	3	4	5	6	7	8	9	10	11	12	13
80	.0125	.003	.002	.0002	0°-45'	0°-30'	.0001		.0002	.0002	.0024	.0003
72	.0139	.004	.002	.0002	0°-45'	0°-30'	.0001		.0002	.0002	.0027	.0003
64	.0156	.004	.002	.0002	0°-45'	0°-30'	.0001		.0003	.0002	.0030	.0004
56	.0179	.005	.002	.0002	0°-45'	0°-30'	.0001		.0003	.0002	.0035	.0004
48	.0208	.005	.003	.0002	0°-45'	0°-30'	.0001		.0003	.0002	.0041	.0004
44	.0227	.006	.003	.0002	0°-30'	0°-20'	.0001		.0003	.0002	.9045	.0004
40	.0250	.006	.003	.0002	0°-30'	0°-20'	.0001		.0003	.0002	.0050	.0004
36	.0278	.007	.004	.0002	0°-30'	0°-20'	.0001		.0003	.0002	.0056	.0004
32	.0312	.008	.004	.0003	0°-20'	0°-15'	.0001		.0003	.0003	.0064	.0004
28	.0357	.009	.004	.0003	0°-20'	0°-15'	.0002		.0003	.0003	.0072	.0005
24	.0417	.010	.005	.0003	0°-20'	0°-15'	.0002		.0003	.0003	.0085	.0005
20	.0500	.012	.006	.0003	0°-20'	0°-15'	.0002	ALL ZERO	.0003	.0003	.0103	.0005
18	.0556	.014	.007	.0003	0°-15'	0°-10'	.0002		.0003	.0003	.0115	.0005
16	.0625	.016	.008	.0003	0°-15'	0°-10'	.0002		.0004	.0003	.0129	.0006
14	.0714	.018	.009	.0003	0°-15'	0°-10'	.0002		.0004	.0003	.0149	.0006
13	.0769	.019	.010	.0003	0°-15'	0°-10'	.0002		.0004	.0003	.0161	.0006
12	.0833	.021	.010	.0003	0°-10'	0°-10	.0002		.0004	.0003	.0174	.0006
11	.0909	.023	.011	.0003	0°-10'	0°-10'	.0002		.0004	.0003	.0191	.0006
10	.1000	.025	.012	.0003	0°-10'	0°-10'	.0002		.0004	.0003	.0211	.0006
9	.1111	.028	.014	.0003	0°-10'	0°-10'	.0002		.0005	.0003	.0234	.0007
8	.1250	.031	.016	.0004	0°-5'	0°-5"	.0002		.0005	.0004	.0264	.0007
7	.1429	.036	.018	.0004	0°-5'	0°-5'	.0002		.0005	.0004	.0302	.0007
6	.1667	.042	.021	.0004	0°-5'	0°-5'	.0003		.0005	.0004	.0353	.0008
5	.2000	.050	.025	.0004	0°-5'	0°-5'	.0003		.0005	.0004	.0425	.0008
4½	.2222	.056	.028	.0004	0°-5'	0°-5'	.0003		.0005	.0004	.0473	.0008
4	.2500	.062	.031	.0004	0°-5'	0°-5'	.0003		.0006	.0004	.0532	.0009

⊕ FOR CLASS 4 SEE N.S.T.C. REPORT 1933 PAGE 58 TABLE 21

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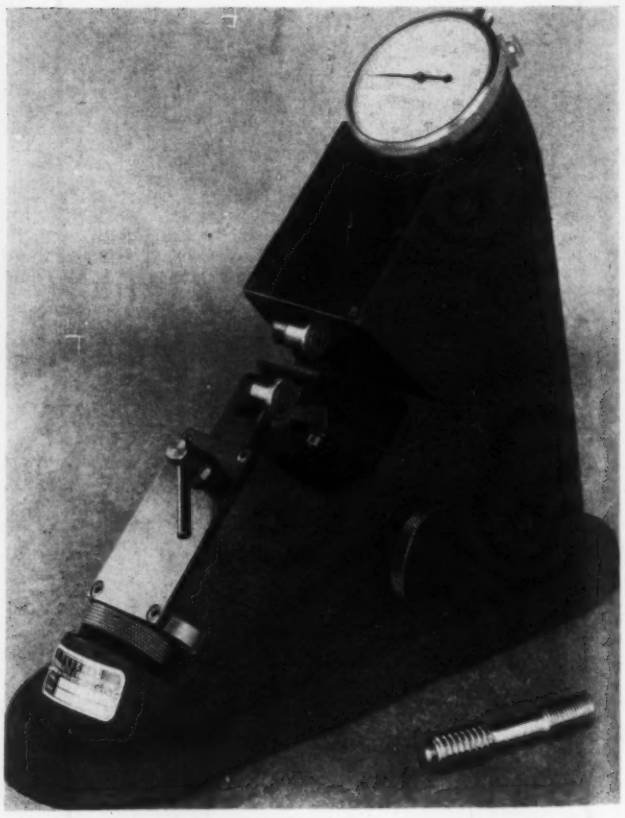

Fig. 9. Indicating thread snap gage. Setting of this gage is the same as the setting of an ordinary thread snap gage. It is easier to use but its accuracy of course depends upon the accuracy of the indicator. It should be noted that this type of gage does not check lead while the thread reel type does.

Figs. 11 and 12 show machines designed specifically for the purpose of the inspection of thread leads.

Thread angle is usually measured by means of an optical projector or comparator.

Gages for External Threads

Gages for measurement of external threads—both thread ring and roll snap—are always mastered. Occasionally, as shown, the measuring standard is in the form of a bar. These are used when the diameter is too great to permit economical use of a plug. Smaller sizes of roll snaps and of thread rings are always mastered with a setting plug.

Design of Thread Gages

Tables 1, 2, 3 and 4, here reprinted, are basic tables used by Army Ordnance in the design of gages. These tables are excerpts from the several design tables for gages in the 1942 Handbook and from the chart "Wear Allowances and Gagemakers' Tolerances, Plain Plug and Plain Ring Inspection Gages" (see Chapter I). These tables are set up on the basis of Class X and are made up from the chart on page 52 of the Handbook Table 17 titled "Recommended Uses for W, X, and Y Thread Gages." From these two charts, all the thread gage specifications are designed. In

Fig. 10. A comparator is here being used for measuring the pitch diameter of a gage. The head contains a ball point designed to the same diameter as a "best wire" for the inspection of the particular pitch. With best size wires underneath the thread gage, this provides exactly the same type of inspection as inspection by the three-wire method.

(U. S. Army photograph)

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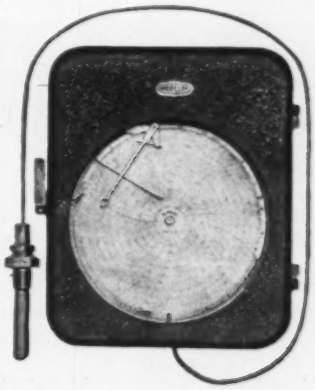

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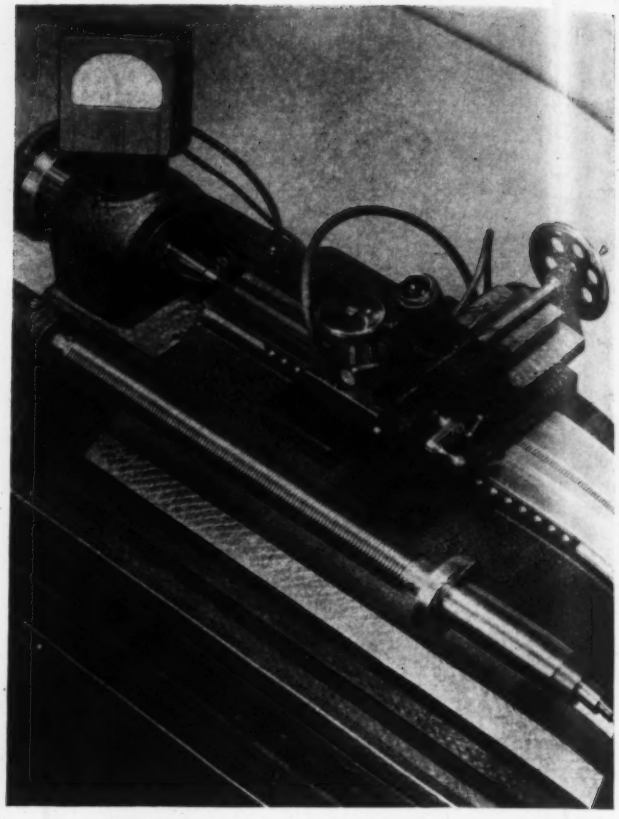

Fig. 11. Lead testing instrument, used for the precision inspection of the lead of a thread. In this illustration it is being used for the inspection of a production item. Equipped with proper magnification it could be used for the inspection of thread gages. Dial shown gives variation from perfect lead in 0.0001 inches.

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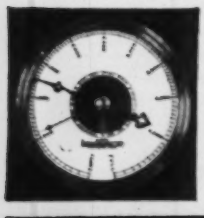

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Fig. 12. The same type machine as shown in Fig. 11 being used for the inspection of lead of a thread gage. Notice that there is a different measuring device used for magnifying the variation but the bed, ways, centers, etc., are the same.

PLAIN GAGES INSP. ALLOWANCES AND TOLERANCES.

	TABLE 2				TABLE 3				TABLE 4			
	FOR CLASS 1 SCREWS				GAGES FOR CLASS 2 3&4 SCREWS.				GAGES FOR ALL CLASSES OF NUTS.			
	MAJOR DIA.				MAJOR DIA.				MINOR DIA.			
THDS PER INCH	TOLERANCES				WEAR ALLOWANCE "GO"	TOLERANCES			WEAR ALLOWANCE "GO"	TOLERANCES		THDS. PER INCH.
	GO	NOT GO	GO AND NOT GO			GO	NOT GO	GO AND NOT GO		GO	NOT GO	
	PLAIN RING	PLAIN RING OR SNAP	COMM. ADJ. SNAP			PLAIN RING	PLAIN RING OR SNAP	COMM. ADJ. SNAP				
	2	3	4		1	2	3	4	1	2	3	4
80	.0002	.0002	.0002	.0002	.0001	.0002	.0001	.0001	.0001	.0001	.0001	80
72	.0003	.0002	.0002	.0002	.0001	.0002	.0001	.0001	.0001	.0002	.0001	72
64	.0003	.0002	.0002	.0002	.0001	.0002	.0001	.0001	.0001	.0002	.0001	64
56	.0003	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0001	.0002	.0001	56
48	.0004	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	48
44	.0004	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	44
40	.0004	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	40
36	.0004	.0003	.0002	.0002	.0003	.0002	.0002	.0002	.0003	.0002	.0002	36
32	.0004	.0003	.0002	.0002	.0003	.0002	.0002	.0002	.0003	.0002	.0002	32
28	.0005	.0003	.0002	.0002	.0004	.0002	.0002	.0002	.0004	.0002	.0002	28
24	.0005	.0004	.0002	.0002	.0004	.0002	.0002	.0002	.0004	.0002	.0002	24
20	.0005	.0005	.0003	.0003	.0004	.0003	.0002	.0002	.0004	.0003	.0002	20
18	.0005	.0005	.0003	.0003	.0005	.0003	.0002	.0002	.0005	.0003	.0002	18
16	.0006	.0006	.0003	.0003	.0005	.0004	.0002	.0002	.0005	.0003	.0002	16
14	.0006	.0008	.0004	.0003	.0005	.0004	.0002	.0002	.0005	.0004	.0002	14
13	.0006	.0008	.0004	.0003	.0005	.0005	.0003	.0003	.0005	.0004	.0002	13
12	.0006	.0009	.0005	.0004	.0005	.0005	.0003	.0003	.0005	.0005	.0003	12
11	.0006	.0010	.0005	.0004	.0005	.0005	.0003	.0003	.0005	.0005	.0003	11
10	.0006	.0010	.0006	.0004	.0006	.0006	.0003	.0003	.0006	.0006	.0003	10
9	.0006	.0010	.0007	.0005	.0006	.0008	.0004	.0003	.0006	.0006	.0003	9
8	.0006	.0010	.0008	.0005	.0006	.0009	.0005	.0004	.0006	.0008	.0004	8
7	.0006	.0010	.0009	.0005	.0006	.0010	.0005	.0004	.0006	.0009	.0005	7
6	.0006	.0010	.0010	.0005	.0006	.0010	.0007	.0005	.0006	.0010	.0006	6
5	.0006	.0010	.0010	.0005	.0006	.0010	.0008	.0005	.0006	.0010	.0007	5
4½	.0006	.0010	.0010	.0005	.0006	.0010	.0010	.0005	.0006	.0010	.0009	4½
4	.0006	.0010	.0010	.0005	.0006	.0010	.0010	.0005	.0006	.0010	.0010	4

computations, a definite routine by types is used, which is as follows:

THREADED RINGS FOR SCREWS

Major dia. "go," cleared; clearance dimension Table I, Col. 4.

Major dia. "not go," cleared; clearance dimension Table I, Col. 3.

Pitch dia. "go" = max. pitch dia. of comp. minus allowance Table I, Col. 8 or 9. Tol. Table I, Col. 10 or 11. Applied minus.

Pitch dia. "not go" = min. pitch dia. of comp. tol. Table I, Col. 11. Applied plus.

Minor dia. "go" = min. minor dia. of mating nut tol. Table I, Col. 13. Applied minus.

Minor dia. "not go" = min. minor dia. nut plus clearance. Table I, Col. 12. Tol. Table I, Col. 13. Applied plus.

Lead, allowable variation in, Table I, Col. 5.

Half angle, "go," class 1 and 2, Tol. on, Table I, Col. 6.

Half angle, Cl.3 "go," Cl.1, 2, 3, "not go," Tol. on Table I, Col. 7.

CHECK PLUGS FOR THREADED RINGS

Note: Tol. on these checks identical with tol. on gage checked.

THREADED CHECKS

Major dia. check for "go" = max. major dia. of screw tol. Table I, Col. 13. Applied minus.

Major dia. check for "not go" = min. major dia. of screw tol. Table I, Col. 13. Applied plus.

Pitch dia. check for "go" = pitch dia. of "go" ring.

Pitch dia. check for "not go" = pitch dia. of "not go" ring.

Minor dia. all threaded checks, cleared; clearance dimension Table I, Col. 3.

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Lead allowable variation, same dimension and tol. as gage checked.

Half angle, tol. on, same dimension and tol, as gage checked.

PLAIN CHECKS

Minor dia. check for "go," same dimension and tol. as gage checked.

Minor dia. check for "not go," same dimension and tol. as gage checked.

TWIN RING OR ADJ. SNAP GAGES

Twin rings used up to and including 0.190".

Comm. adj. snaps used above 0.190".

TWIN RING

Major dia. "go" = max. major dia. of screw minus wear Col. 1, Table 2 or 3. Tol. Col. 2, Table 2 or 3. Applied minus.

Major dia. "not go" = min. major dia. of screw. Tol. Table 2 or 3, Col. 3. Applied plus.

COMM. ADJ. SNAP

Major dia. "go" = max. major dia. of screw. Tol. Table 2 or 3, Col. 4. Applied minus.

Major dia. "not go" = min. major dia. of screw. Tol. Table 2 or 3, Col. 4. Applied plus.

THREADED PLUGS FOR NUTS

Major dia. "go" = basic major dia. comp. tol. Table I, Col. 13. Applied plus.

Major dia. "not go" = basic dia. comp. minus clearance Table I, Col. 12, Tol. Table I, Col. 13. Applied minus.

Pitch dia. "go" = min. pitch dia. comp. plus allow. Table I, Col. 8 or 9 tol. Table I, Col. 10 or 11. Applied plus.

Pitch dia. "not go" = max. pitch dia. comp. tol. Table I, Col. 11. Applied minus.

Minor dia. "go," cleared; clearance dimension Table I, Col. 4.

Minor dia. "not go," Table I, Col. 3.

Lead, allowable variation in, Table I, Col. 5.

Half angle, "go," class 1 and 2, tol. on, Table I, Col. 6.

Half angle, class 3, "go," and class 1, 2, 3, "not go," tol. on, Table I, Col. 7.

PLAIN PLUGS FOR NUTS, MINOR DIA.

Minor dia. "go" = min. minor dia. comp., plus allowance, Table 4, Col. 1, tol. Table 4, Col. 2, applied plus.

Minor dia. "not go" = max. minor dia. comp. Tol. Table 4, Col. 3, applied minus.

DERIVATION OF CLEARANCE ON TABLE I

Values shown in Column 12 are obtained as follows:

$h/3$ minus values shown in Col. 13.

The above is, of course, not used for standard threads marked "NC" or "NF" inasmuch as the tolerances for all of these gages are already set up in the Handbook.

Army Gets Latest Advice on Combustion Control

THE United States Army, now the country's biggest landlord, is sponsoring special training for a group of its combustion engineers to make sure that the hundreds of camps and scores of hotels in which its troops are housed are efficiently heated with greatest possible fuel economy.

The selected staff of officers recently completed an intensive course of training at the school operated by the Brown Instrument division of the Minneapolis-Honeywell Regulator Co. The Brown school, which has been training men from many ordnance and war plants in the use of industrial instruments, arranged a special course for the officers. They learned about the use and maintenance of flow meters, CO_2 meters and the "Protectoglo" automatic safety device.

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AMOIL-S	3.1×10^{-6} mm.	111.0°C.	500 g. — 12.00
OCTOIL	2.5×10^{-7} mm.	122.5°C.	500 g. — 17.00
OCTOIL-S	5×10^{-8} mm.	143.5°C.	500 g. — 20.00

*These pump fluids are protected by U. S. Patents 1,857,508; 2,147,479; 2,147,488

†Measured with an ionization gauge at 25°C., using Glass Three-Stage Fractionating Pump

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Speeding Up Air Flow Measurements

(Concluded from page 58)

This type of device is usually designed to operate on a 6" differential with an inclined scale approximately 48" long. Provisions are made for varying the inclination of the tube to compensate for variations in absolute pressure within a range of about 28" to 31" of mercury and in atmospheric temperatures over a range of 30 to 160°F. Likewise, a multiplicity of scales (up to 14) mounted on a drum are available, each scale being calibrated to correspond to one adjustable orifice setting. In the usual installation it therefore is possible to provide adjustable orifice settings and manometer scales, corresponding to the standard conditions of 29" of mercury absolute pressure and 80°F. temperature for which the inclined-tube manometer is basically designed; and to correct for variations from this temperature and pressure by changing the vernier scale adjustments. Likewise, when a change in orifice setting is desired, the proper scale can be brought into service by rotating the drum by means of the scale indexing knob.

A number of "Meriam Inclinometers" are being used today with air bottle systems for aircraft engine and carburetor testing. These same instruments can be used if adjustable orifices are substituted for the air bottles, since the flow-differential characteristic of an adjustable orifice is substantially the same as that of an air bottle system "orifice." Also, the same scales can be retained on the "Inclinometer" if capacity settings are unchanged. Modified "Inclinometers" are also available for installations where the variations in temperature and pressure exceed the values that can be accurately handled with the standard compensator adjustments.

SPECIAL TESTS

When aircraft engine and carburetor manufacturers first considered the use of adjustable orifices, it was realized that the approval of both the Navy and Army Air Force authorities must be obtained for the use of this device. Units ranging in size from 8" to 20" are already in service at the Aeronautical Engine Laboratory of the Naval Aircraft Factory. However, until recently, the requirements of the U. S. Army Air Forces Matériel Center at Wright Field resulted in the extensive use of their Air Measuring System which employs an air bottle system with a series of separate air bottle "orifices" or "nozzles" to measure the requisite wide range in air flow.

In order to determine whether results obtained with adjustable orifices were as trustworthy as those obtained with the Army Air Forces Air Measuring System, tests were made at Case School of Applied Science, in which a Bailey Adjustable Orifice and a standard air bottle system were installed in series in the same pipe line, together with one of several high-precision thin-plate orifices which had been previously calibrated in the Ohio State University Hydraulic Laboratory and approved by the National Bureau of Standards.

These tests demonstrated that a predetermined series of settings on a single adjustable orifice could produce results which were directly comparable with the readings obtained with the air bottle system, and that the results obtained with the adjustable orifice could be reproduced from day to day. It was further demonstrated, by comparison with the readings of the standard orifices, that both the adjustable orifice and air bottle systems are accurate.

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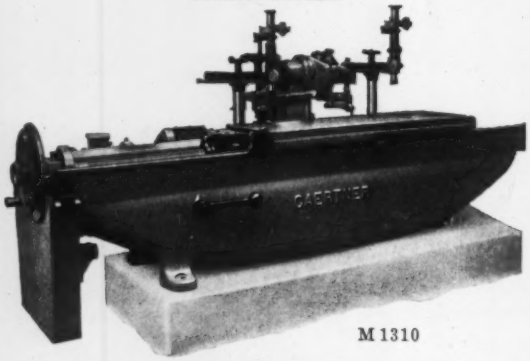

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America's Patent Law

Statement by John W. Anderson, President, The Anderson Co., Gary, Indiana, to the Senate Patent Committee, October 23, 1942

EDITOR'S NOTE—*Here is that "editorial on dangers to inventors" requested by a number of readers—written by "one of us" who (as you will see) is better qualified than —M.F.B.*

I AM a "small-town" American now fearful that our Congress and our Courts may be persuaded, under the pressure of prevailing panic, innocently to translate that panic into permanent paralysis.

I am not a lawyer—patent or otherwise.

I am merely President and General Manager of a company operating a small manufacturing business which I founded in 1918—to manufacture products embodying new inventions. Our company operated in its early years with a small amount of capital—contributed by "butchers and bakers and candlestick makers."

Like most men heading and managing one of the thousands of American manufacturing businesses devoted to the creation, production and distribution of products contrived to better serve the needs of the public, I get my "recreation" almost entirely by shifting my working hours, which average about fourteen per day, from the headaches of the experimental laboratory to problems of production, finance or sales, and in recent years to new and vital problems created by changing conditions basically affecting all business and all public interests.

During all of these years my golf clubs, guns, cameras and fishing tackle, usually suggestive anniversary presents from employees and other friends, have served almost entirely as symbols of hopes deferred.

My experience in the patent field began with my first application for a patent, which I filed when I was about nineteen. During the forty years since elapsed I have dealt almost constantly with activities generated in one way or another by patents.

My company owns a number of patents and during its twenty-four years has developed and marketed widely a variety of products embodying inventions of its own employees and of others.

In some instances we have taken, from outside inventors, licenses on which we have paid royalties. Some patents we have bought outright. In other instances we have paid substantial bonuses and royalties to our employees for the use of their inventions—which they had no other means of making available to the public.

On inventions acquired from one employee, thousands of dollars per year in royalties have been paid—in addition to a liberal salary. This inventor some years ago went into business for himself and, to obtain capital, sold his license contract to others, to whom we paid last year ten thousand dollars in royalties. To another inventor retaining an interest in another patent on one of his inventions we paid last year fifteen thousand dollars in royalties.

Inventions not suited to our facilities for production and distribution we license to others. Under one license contract a single licensee has made and sold more than fifteen million automotive electrical instruments for civilian use and is now supplying those instruments in large quantities for use by our armed forces.

When the Army recently sought competitive sources of supply of other products made exclusively by us and covered by patents owned or controlled by us, we voluntarily offered to license other manufacturers, including our principal competitor on such products, to compete with us for Army business royalty-free, in spite of the fact that our productive capacity on such products exceeds by three or four times the total foreseeable requirements of the Army.

A manufacturer selected by the Army for such purpose was licensed by us to make such products for Army uses, royalty free.

The foregoing of royalties on our products made by others under such licenses for the Army we regard happily as one of our contributions to the war effort—a contribution which fortunately we can afford. While we feel strongly that any patent useful in the war effort should be drafted, if not otherwise available, we do not feel that it would be fair in all cases to permit the inventor or patent owner to forego compensation in the form of a royalty—any more than it would be fair to permit any other kind of laborer to donate his services or to require that other property or saving be drafted without compensation.

Inventors are indeed but laborers. I have heard during my lifetime a great deal about men of "genius"—popularly assumed to be men possessed, in the form of a gift, of some weird labor-saving talent denied to most others.

I have never met such a man. I have met men of varying capacities—and of varying inclinations toward the development of their capacities—but I have never met a "genius."

When I read of some highly publicized "genius" such as Edison or Steinmetz, I am told also how that man, in pursuit of his objectives, secludes himself in almost uninterrupted preoccupation with his problems—to such an extent that interested friends often intervene to persuade the "genius" to take more rest and eat more regularly.

My observation and experience, therefore, have convinced me that, as has so well been said, "genius is but a capacity for taking infinite pains." There exists nowhere to the contrary any evidence worthy of consideration by any court charged with meting justice to earth-bound citizens.

To hold that "genius" exists as a somewhat involuntarily exercised "gift from the Gods" is to ignore the lessons of human experience, which lessons teach that strength and skill, either physical or mental, are developed only by repetitive and sustained effort.

Those reluctant to match such effort perhaps invented long ago the word "genius" to designate a mystic power which they were presumed unfortunately not to possess, as a convenient "alibi" for their preference for diversified activities.

Prolific inventors invariably are men who have abjured indulgence in physical and mental diversions commonly enticing. Such men, usually in seclusion, give to the problems of producing better mouse traps and more useful other things a devotion often unsurpassed even in the field of religion.

There is nothing spectacular in the unpublicized and limitless hours of mental and physical concentration which such men have schooled themselves to give to such problems. This concentration at times involves almost total social, physical and financial sacrifice in pursuit, over a period of years, of a single invention which, when achieved, in itself may appear so simple as to offer no hint, even to a mind schooled in judicial procedure, of the grueling labor and heart-breaking disappointments which have measured the price of the achievement.

During the past forty years I have lived for long periods that kind of life, in association with others similarly consecrated. I have known intimately many of those thousands of men throughout America who form that patient army which, since the establishment of our patent system, has battled persistently to provide for all our people a greater abundance of those things which have made the lives of Americans more fruitful than those of any other nation known to history.

Many times I have persuaded such men to drop their tools for too-long-neglected food and rest. I have literally picked them off the floor in a state of complete physical collapse, only to have them come back eagerly to their inventive task before their returning strength would justify.

I have shared with these men both the disappointments of repeated failures and the joys of final achievement with its financial rewards. I have sensed their confident reliance

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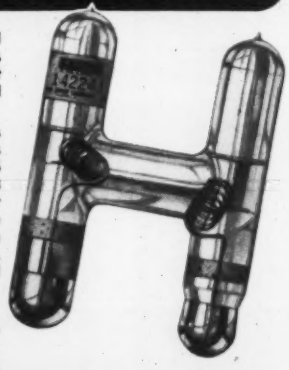

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upon the equities of our patent laws, a reliance without which they could not have sustained their efforts.

Also supporting these men is usually a devotion to the welfare of their intimates, at home and in the laboratories. Only an extraordinary capacity for undiluted devotion, plus a confidence in the equitable application of patent laws promising financial reward, could possibly sustain them. Except in rare cases, such financial reward alone has enabled such men to avoid the necessity of accepting employment offering no opportunity for invention.

Few men, if any, could be impelled to endure such sacrifices merely by the doubtful prospect of gratification from unrewarded and unappreciated contributions to the welfare of millions of other men. Human nature hasn't changed. It still is actuated on the one hand by a desire to avoid punishment and on the other hand by a desire for achievement and reward. Systems which disregard these truths invariably fail.

Any conception of the underlying intent of our patent system as a means for rewarding incandescent and sporadic flashes of God-given genius—which flashes do not exist—imposes upon our courts the impossible task of discovering, years later, that residue of cinders presumed to have been left by the flash. It imposes likewise upon the courts the necessity for endeavoring to retread in reverse that thorny path trod by the inventor in search of the invention, to determine at what point that lightning flash of divinely inspired "genius" is to be presumed to have disclosed, ready-made, to the struggling inventor, his finished invention as it would finally appear in a patent drawing.

Such presumption is clearly a throw-back to prehistoric days when mankind invented divers gods and their foibles to account for phenomena which mankind could not understand.

Conversely, we perhaps should not withhold admiration for the modesty of any authority who is unable to find "invention" in any product which, when finally conceived and produced, looks so simple he can readily understand it.

The complicated and often intriguing "Goldberg" approach to an inventive problem is usually the first and the easiest approach. Whenever I see a "Goldberg" device—in a comic supplement or in a laboratory—it reminds me of a famous postscript by a famous man (I think it was Benjamin Franklin) who wrote, "Pardon the length of this letter. I had not the time to write a short one."

The road from the "Goldberg" approach to a simplified, practical result—a manufacturable and usable result—is often a long and exhausting road. And as the product, through patient steps toward simplification, accumulates dignity and merit as an invention, it usually — to those whose custom is to contemplate rather than to create—looks less and less like a pattern cast up in convulsion by some helpless soul caught in that phantom crucible of "inventive genius"—and therefore to them looks less and less worthy of patent protection.

The Constitution granted to our Congress broad powers as to patents, in the following words:

"The Congress shall have power to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

I see in this grant no mention of "genius"—perhaps because our founding fathers knew too well that the price of all worth while discoveries is persistent effort.

It would seem that Congress might today relieve embarrassment of our courts by finding some way to assure the courts of its desire that the findings of the experts in the Patent Office, as reflected in the patents they permit to issue, be given the same weight, in support of the presence of invention entitled to protection, as is given by our courts today to the decisions and rulings of other less seasoned agencies of our Government.

The trend of court decisions today suggests strongly that the courts feel an obligation primarily to search for the phantom cinders presumed to have been deposited at the

instant of that ghostly flash of "genius" for which the end-product of persistent patience is so commonly mistaken.

By what conception of consistency does any court ever crown any inventor as a "genius" and a particular invention of his as reflecting "inventive genius" when all who are experienced in the job of creating a new product know that usually the inventor conceives, tries and discards from seven to seventy ideas and models before he, through his patient step-by-step persistence, reaches his goal? Surely the "percentage," on the theory of "genius," is against him seven to one or seventy to one. If the inventor fails six to sixty-nine times, how can he suddenly become a "genius" because at last, surrounded by his litter of discarded models, he finds the answer?

Can a man for 364 laborious days be merely a "mechanic skilled in the art" and then, suddenly, on the 365th day, become a "genius" qualified for recognition as such by any authority?

Would it not be more practical and more inspiring to that patience which is so innocently termed "genius"—and much more productive of public benefits—were our Congress and our courts to reshape the superstructure of our patent system in such ways as may seem desirable—without destroying its very foundation—to the end that a patent may be presumed to be something more than a challenge to our courts to search for cinders and an invitation to piratical manufacturers to purloin that which they have been too lazy or too preoccupied to create?

People seldom plant gardens where thieves abound and police protection is inadequate. Pirates are everywhere and inventors will not continue to invent, nor will small investors support their inventions, if patent rights are not sympathetically protected.

Recently one inventor, whose inventions for years have been serving millions of Americans, and who is now working long hours and almost beyond the limit of his strength to perfect a product critically needed in our war effort, told me of his discouragement by the persistent attacks upon our patent system and of his plans to retire from all inventive work just as soon as he could feel that he had fully discharged his obligations to his nation at war. The loss of that one man's interest and efforts may mean as much to America as the loss of a sizable island possession.

No man who hasn't pursued an elusive invention through fatiguing days and restless nights—no man who hasn't tasted the bitterness of repeated failures and the all-too-infrequent and often too-long-delayed joys of final success, could possibly appreciate the submerged romance of sacrifice which has produced and is still producing that wealth of unequaled advantages enjoyed by our people today, and promised in greater abundance for our people tomorrow provided only that the incentives of our patent system are continued.

It is understandable why those who see only the professionally publicized abuses of our patent system, and cannot sense fully its importance as a basic factor in sustaining our national life and in providing for us sciences and industries—plants and products—for our protection against international gangsters now rampant, exhibit such commendable fervor in their attempts to correct abuses by disabling the system itself.

That most such men are conscientious in their crusade against our patent system is not denied. But conscientious fervor can be constructive only when growing out of complete understanding.

Tradition has it that the conscientious farmer's son, who on one cold winter night set fire to the barn to keep his pet pony warm, was not chastised by his understanding father. Neither should those whose "pet pony" is the "small manufacturer" be condemned because they seem determined to burn down the patent office to keep the small manufacturer warm.

Parents are presumed by right of law to control their children until of age. The mere fact that a patent grants, for a brief period of 17 years, control of the manufacture, sale and use of the "brain child" of the inventor does not

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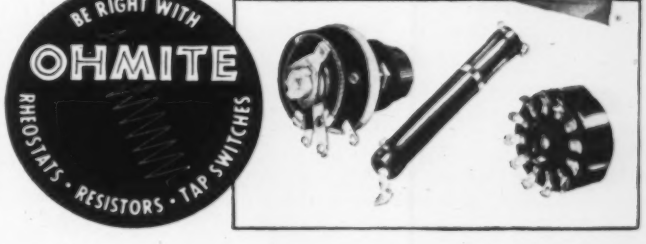

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imply that, since monopoly of one kind may be bad, the grant of that brief period of control offered as an inducement to inventors to continue to invent is necessarily also bad. Quite the contrary is true.

We have heard much in recent years about the need for protecting the small business man—against monopoly. But it has seemed instead that what the small business man often needs most is protection from his self-elected protectors.

Neither the public nor the Congress seems to possess adequate understanding of the potent fact that were the patent system discontinued or seriously weakened today the small manufacturer could not hope to survive against the great weight of capital, production facilities, technical personnel and entrenched distribution of his larger competitor.

Destroy or seriously weaken our patent system and thousands of small manufacturers throughout America, who rely upon patented features of their products to make those products more serviceable to the public, will soon thereafter be forced to disappear and leave the field to the giants of industry, and the public to the whims of those giants.

Instances where patent protection alone has enabled a small manufacturer, almost from a standing start, to develop his better products and his business against strongly entrenched competition are numerous. The benefits which such manufacturers have brought to the public have been in the aggregate of tremendous importance.

One outstanding example is found in the field of production and use of steel tubing, such as for petroleum pipe-lines. Here a comparatively small manufacturer, through financial gamble, relentless concentration and sweat, perfected and patented a process for making steel tubing faster and cheaper—steel tubing which could be sold for less and which could be laid for less. A giant corporation had just completed a mammoth plant for making such steel pipe by older and more costly methods.

At least a conventional return on the many millions of dollars invested in that mammoth plant was to be taken in profits to be added to the cost of making that tubing by the then accepted processes. This meant that these established costs and a reasonable profit would have to be included in selling prices, in the form of a tax which would penetrate clear through to all users of gasoline and other products made from petroleum transported through those more costly pipes.

The smaller competitor, under the protection of his patents, has been able to defeat that giant corporation in the manufacture and sale of tubing, but only because his cheaper and better tubing reduced that tax—to the benefit of the public.

In another field, one company, through the protection of patents on features which give to the users of its products, which sell at less than a dollar each, more and better service per dime invested than they could get from the products of a multi-million-dollar competitor who had practically dominated that field, has been able to make its products conveniently available to all potential users and to earn, from its sales of these products, profits out of which it has continued the refinement of those products so that now in wartime their advantages are relied upon to facilitate combat and other operations of our Army and Navy, on land, on sea and in the air.

The inherent vitality of our economy in America has generated largely from such monopoly-leveling competition. The small manufacturer asks only for a fair chance to out-invent, out-manufacture and out-sell his giant competitors. Usually he can get a washing on the line before his corpulent competitor can find the soap.

Thus America's unsung inventors—and those who produce and distribute their inventions—continue, and until incentives are removed will continue, to make our homes and our living in America productive in a single life's span of more of that which makes for human progress than our forefathers enjoyed throughout centuries.

Look about your home today—the kitchen, the living room, the bedroom, the bathroom. Try to count the time-

saving and health-promoting improvements unknown to our grandfathers. Look for those little marks on the bathroom fixtures, kitchen utensils, bed casters, alarm clocks and the many other things to which, in your homes, you have become so accustomed as to be scarcely conscious of their existence.

Those little marks are patent numbers, or notices of "patent pending"—or perhaps the patent has expired long since and the mark is omitted—with the invention dedicated to the public. Whenever you see such a mark, give a thought, and your thanks, to the man or men who neglected their meals and perhaps borrowed or begged, to keep going while they sought a way to make a new product for you, or to make an old product better.

The next time you ride in an elevator in a public building please wonder how many men have contributed to the improvements which made the modern elevator, and therefore our modern skyscrapers, possible. And the next time you listen to your radio, use your telephone or ride in your automobile or in a train, boat or airplane, please lift your hat in tribute to those many patient men who, bit by bit, day by day, and night by night, pieced together, perhaps while you were at cards or at golf, the pattern of the things which serve us all in our day—things which were beyond the reach of kings and potentates throughout centuries of recorded history.

To appreciate what this broad service means let us also remember that the perfection of an invention is but the first of three hazardous steps important to the public. The invention must be manufactured. That takes money and specialized experience. The invention must be brought to the attention of those who may need it, and must be made readily available to them. That takes more money and more specialized experience. All three steps involve risk which requires courage based upon reasonable assurances.

Somewhere on the road from the inventive idea to the public market some of these ventures fail. But out of the multitude of such efforts come the many things which make for a fuller and finer life for all our people.

Without the assurance of consistent patent protection makers and distributors of patented products will not be persuaded to continue to risk the capital and effort necessary to put such products within easy reach of the public.

No small investor will blindly risk his money and labor to make a new and better product available to the public if, when his market has been organized, dozens of piratical manufacturers, with no investment of time, money or effort in pioneering his product or its distribution, can copy that product—with no fear of our courts—and thus rob him of all chance to recover his investments or to receive any reward for his service.

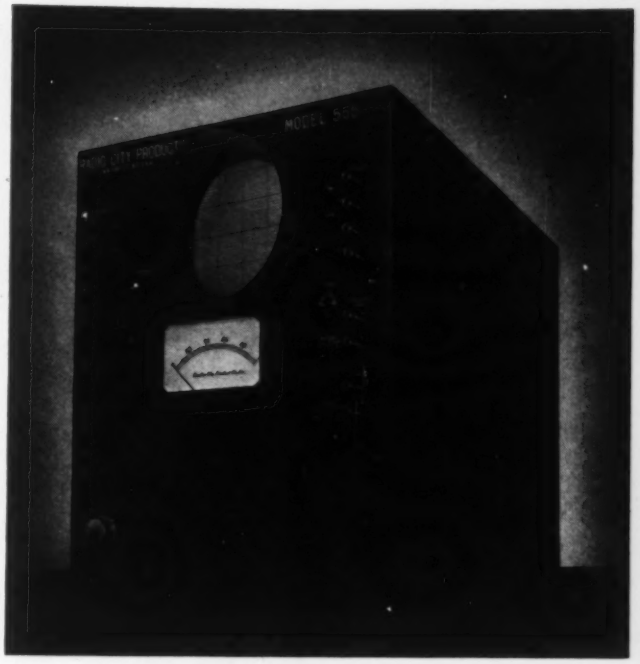
Many products valued today by the public would never have reached and served the public except for patent protection. Thus our patent system stimulates not only the invention of better products but also their production and distribution.

Long ago a Patent Office Examiner is said to have resigned, stating as his reason that all the great inventions had been invented and that there was little left for the Patent Office to do. Little did he suspect that he had seen only the beginning of what our patent system would add to the strength of America and to the joy of living in it.

There are among us today many of similar spirit who feel that our technological frontiers are closing, or should be closed, and that we may safely discourage invention and freeze industry, although unable to place any similar restrictions on the inventors and producers of other nations.

Let us suppose that the crusaders of another year had been successful in their efforts to brand the inventors of labor-saving machines as public menaces—and had stopped all progress toward faster and cheaper production. Whose thanks would they have earned—and whose pay?

We are now told that the full-time labor of many persons is required behind the fighting front to equip, transport and maintain a single soldier. Without the help of our better processes and machinery invented since the last



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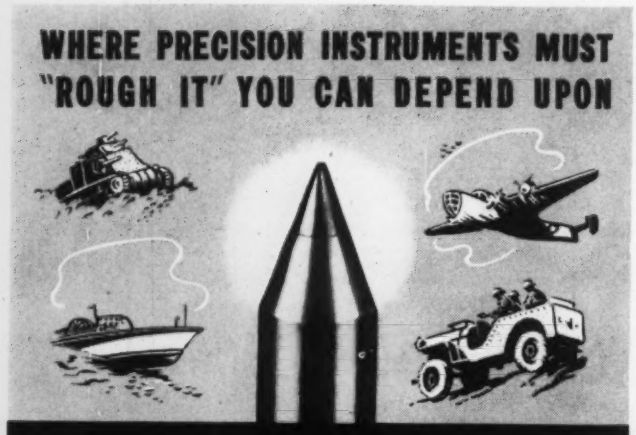

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It is made in several standard ranges from 20 F.P.M. to 6000 F.P.M. and up to 3 inches static or total pressure. Special ranges available as low as 10 F.P.M. and up to 25,000 F.P.M. velocity and 20 inch pressure.

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Illinois Testing Laboratories Inc.

Don't you know

142 West Hubbard Street Chicago, Illinois

World War, might we not be hopelessly outclassed in the present competition for war production?

For generations the Japanese and other races have been encouraged to borrow heavily from our inventors, have added some improvements of their own and have now attacked us in warfare mechanized largely by our own inventions.

Should we today encourage or permit any group or block of men, however inspired, to persuade us to destroy the incentives which inspire our own inventors to keep our products and our industries—and our country—ahead of all world competition? How long could we survive as a nation if we did? And how free have we been, or would we be, to borrow our means of progress and protection from other nations?

Were it my task, as a super-saboteur, to destroy America, I should certainly want to begin by disabling her patent system, thus to sterilize her entire economy.

In that program of destruction I should hope to confuse and enlist conscientious Americans possessing unusual talent and appetite for catching and holding the public eye for headlines, and capable of great crusading flights of cloud-based inspiration.

I should hope that such innocent crusaders could command for propaganda purposes sufficient public funds to so completely indoctrinate the people of America and her courts as finally to implant virtuously in her patent system some plausible "improvement" which would add to the hardships and uncertainties of invention just enough to break the will and heart of every man capable of invention and of every man with ability to make and distribute new and better products.

Possibly a system of annual taxation of patents would be sufficiently discouraging. Britain for years has had such a system. During those years her manufacturers have been combing America for licenses to make products originating here and patentable in Britain.

If annual taxation of patents failed to slow up our inventors adequately no doubt some form of compulsory licensing system could be made to turn most of them toward routine pursuits.

And if the patent law could be amended to compel the patent owner first to ferret out and identify a piratical manufacturer infringing his patent—and then sue that manufacturer successfully before any suit could be brought against a distributor—I think the pirates would soon destroy practically all of the value of the patent system to any but our largest manufacturers.

There have existed across America for years underground chains of distributors who fatten on the sly distribution of infringing products secretly manufactured by "professional" pirates who are highly skilled in the art of concealing their operations and of finally leaving nothing behind but the shell of an abandoned corporation from which no damages can be recovered. Reputable manufacturers have spent annually in the aggregate vast sums, endeavoring to locate and identify such secret sources of piratical infringements. If a reputable manufacturer could not proceed against distributors of infringing products without first finding and suing successfully the secret source of such products, that reputable manufacturer could be virtually wiped out of his markets and wrecked financially before he could even discover who was making the infringing product.

With a patent owner compelled first to find and sue successfully the infringing maker, whether openly or secretly infringing, the tendency of piratical manufacturers to migrate to Federal Districts and to Federal Circuits known to have least respect for patents would of course accelerate. From such vantage points the production of copies of the other fellow's creations could be continued with greater impunity—and with proportionate unfair damage and discouragement to those who create. Under such conditions interest in inventing, manufacturing and distributing new and better products would decline—in all Districts.

In times of confusion talented talkers have seemed able

always to find exciting words and enticing theories with which to disable the patient builders of a nation—and perhaps innocently to destroy that nation itself—more spectacularly perhaps than those talkers could find for themselves the tedious ways in which to help their neighbors build.

If we permit ourselves to be talked into disabling our patent system and thus dishearten the most vital volunteer force ever to serve America—that inventive force without which America could never have been strong—I think we may some day ask the Japanese to yield to us for all time their standing as the world's leading exponents of harakiri.

Should we not instead religiously maintain adequate incentives in our patent system and devote our thought and energies to improving and supporting that system to make it even more productive of inspiration for inventors and of resultant benefits to all our people?

I do not profess ability to define desirable improvements in our patent system, or to outline procedure for achieving them—nor do I suggest that we shall ever be able, as to any system, for any purpose, to so perfect it as to hold it free of abuses.

But I do urge that we abandon, in our dealings with the patent system, the disabling theory, smacking of spiritualism, that the intent is to reward only those nonexistent mental monstrosities to whom angels are presumed to present on a silver platter a clear solution of a difficult problem of invention.

Let's instead confess our complete reliance upon the consecration and perseverance of earth-bound mentalities, and let's keep alive and intact, in our patent system and in the courts upon which it must rely for support, the inducements which have kept so many men, of varying inherent abilities, working toward greater abundance and greater security for us all.

Then let's keep intact also the inducements which for so long have inspired men of management who, under our free enterprise system, have performed so well in directing men, money and machines toward serving our public with the fruits of invention.

Make those men manage fairly—but keep them inspired and free to carry us ahead in world competition—for peace or in war.

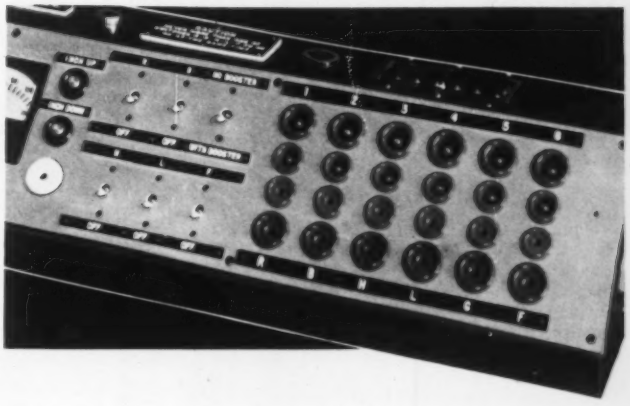
Instrumentation at Pitt

Under the direction of J. A. Pelletere, three ESMWT courses in instrumentation are being given at the University of Pittsburgh:

General Instrumentation—To provide training for persons who have had industrial experience in the use of recording and automatic control instruments, and give them an understanding of the underlying principles. Theory of pneumatic control in simple and complex units; Temperature instruments based on expansion, radiation, color and photoelectric elements; Level instruments; etc. Application of various instrument types to process control.

Advanced Process Control Instrumentation—To provide a complete understanding of commercial unit instrumentation. Air control theory as applied to combustion controls; Wheatstone bridge instruments with a complete analysis of one commercial unit of each type; Theory of electronics as applied to present-day pyrometry, etc. A feature is the detailed study of complete commercial installations.

Thermionic Control Instrumentation—To provide a complete understanding of present-day high-speed instruments. The course includes basic training sufficient for understanding application of photocells and chopped d-c. input circuits. Basic coverage is also included for resistance-coupled and direct-coupled low-frequency amplifiers and simple oscillator circuits; complete analysis of four commercial instruments which operate without galvanometer to command a reversible motor to drive the recording pen directly.



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Instrument Societies

BALTIMORE

Our president, Mr. Baker, was forced to resign because he has departed from the city and is now in the U. S. Navy. He has been succeeded by Mr. Byron M. Dewey, formerly Vice-President, whose address is Severna Park, Maryland.

Our meetings have been well attended and I believe the society has a firm foundation upon which to build now. Our average attendance has been between 40 and 50 which can be considered very good when travel conditions in the East are considered.

—FRED PULLEN

CHICAGO

The January meeting of the Chicago Society for Measurement and Control was held at the St. Clair Hotel on Monday night, January 4th. Only a fair number of members and guests attended this meeting, which might possibly have been attributed to the bad weather prevailing on this day.

The subject of the technical discussion for the evening was "Methods and Apparatus Used for Flaw Detection." Speakers for the evening were Mr. Frank O. Fischer, Resident Engineer of the Magnetic Analysis Corp., Mr. George A. Russ, Commercial X-ray Operator with C. S. Gordon Company and Mr. W. E. Thomas, Assistant Sales Manager of the Magnaflux Corporation. Mr. Fischer spoke on an electrical means of flaw detection, Mr. Russ discussed X-ray practice and Mr. Thomas discussed the use of magnetic powders. Each speaker discussed the advantages and disadvantages of each method. The meeting was both instructive and enjoyable. —J. A. RIGGS

NEW YORK

Forty attended the dinner which preceded the Jan. 26 meeting, which had an attendance of sixty.

The following officers were elected for 1943. *Pres.*, C. O. Fairchild, C. J. Tagliabue Mfg. Co.; *Vice Pres.*, P. G. Weiller, Kollsman Instrument Div. of Square D Co.; *Sec'y*, R. K. Farnham, Instruments Publishing Co.; *Treas.*, E. Corbett, C. J. Tagliabue Mfg. Co.

This is Your Page, Society Members!

So see to it that your Secretary or Publicity Chairman uses a piece of it every month—as we have been urging them to do. Instrument societies can help in the War Effort as societies, in addition to the fact that most members belong to

The 10% Club

In addition to these, the following were elected to serve on the Executive Committee: J. C. Banks, New York School of Aircraft Instruments; Lieut. H. R. Kalbfleisch, U. S. Navy; Ward O'Conner, the Lummus Co.; Herbert Proshe, Wheelco Instruments Co.; J. E. Warren, Nelsson Electrical Labs, Inc.

George Kauer, who has served so well as acting chairman since September, then turned the meeting over to President Fairchild who introduced the speaker J. C. Peters of the Leeds & Northrup Co.

Mr. Peters discussed "Important Considerations in the Application of Automatic Control" with special emphasis on the necessity for having proper characteristics in the valves used in a control system. Almost everyone seemed to contribute to the discussion which followed Mr. Peters' remarks.

Mr. Fairchild's will be an active presidency and our membership looks forward to a progressive year under his guidance.

—BOB FARNHAM

PHILADELPHIA

The Philadelphia Society for Instrumentation sheds its baby clothes, now fully organized, with a bang-up attendance of eighty at the January 20th meeting, and sixty as fully paid-up members.

The old standby, Mercury-in-glass Thermometry, was the subject of Mr. W. D. Laverell's talk of the Precision Thermometer and Instrument Company, of Philadelphia. He went on through the early history and evolution of the present-day thermometer, with a complete array of demonstration samples. The various manufacturing steps involved and features of design were also discussed. His entire talk was very instructive and full of timely information.

The discussion which followed was quite lively and brought out some very interesting points on Thermometers.

—GEORGE HAMMER

INSTRUMENT SOCIETIES CALENDAR

City	Society	Secretary	Date	Place	Subject	Speaker
Atlanta	Georgia Society for Measurement & Control	D. D. Beach, P.O. Box 4569, Atlanta, Ga.				
Baltimore	Baltimore Industrial Instrumentation Society	Fred Pullen, Bethlehem Steel Co., Sparrows Point, Md.				
Chicago	Chicago Society for Measurement & Control	Carl Hope, 2626 W. 31st Blvd., Chicago	Mar. 1(B)	St. Clair Hotel	Sound & Vibration Measurements	H. A. Leedy, Armour Research Foundation
			Apr. 5(B)	St. Clair Hotel	Measurements of the Magnetic Properties of Metals	Kenneth L. Scott, Western Electric Co.
			May 3(B)	St. Clair Hotel	Substitutes for materials used in instrumentation	(To be announced) Tech. Chairman, E. C. Rieger
Hartford	Hartford Society for Measurement & Control	Stephen J. Zelle, Whitney Chain & Mfg. Co., Hartford, Conn.	Mar. 16(D)	Hartford Electric Light Auditorium	Surface Finish Standards	W. Mikelson, GE Lab.
			Apr. 20(D)	Hartford Electric Light Auditorium	Gage Clinic	(To be announced)
Newark	New Jersey Society for Measurement & Control	R. F. Robey, 409 Orange Ave., Cranford, N. J.				
New York	New York Society for Measurement & Control	R. K. Farnham, 545 Fifth Ave., N. Y. C.	Feb. 23(B)	Churchill's Terminal Restaurant	Instruments, the Buyer and the Seller	P. G. Weiller, Kollsman Instr. Div. Square D Co.
			Mar. 30(B)	Churchill's Terminal Restaurant	Instrumentation in the Weather Service	C. H. Colvin, Dir. Guggenheim Aero Sch., N.Y.U.
			Apr. 27(B)	Churchill's Terminal Restaurant	(To be announced)	H. C. Roters, Dir. Research, Fairchild Aviation Corp.
Philadelphia	Philadelphia Society for Instrumentation	George Hammer, Foxboro Co., 701 Otis Bldg., Phila., Pa.	Mar. 17(B)	Engineers' Club	Instrument Maintenance in an Oil Refinery	M. H. White, Gen. Fore'n Atlantic Ref. Mech. Lab.
Pittsburgh	American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St., Pgh.				

(A)Meeting at 7:30, no dinner. (B)Dinner at 6:30, meeting at 8. (C)Dinner at 7, meeting at 8. (D)Meeting at 8, no dinner.

Manufacturers' New Literature

In this department we report ALL pieces of new literature pertaining to Instrumentation, received from the manufacturers. To assist in the War Effort we urge readers to request ONLY those bulletins which will be of value to them. Use the no-stamp-needed card below.

K-57 **Plug Gages.** Bulletin 42, 8½" × 11", 12 pages, illustrates and lists sizes, tolerances and prices of plug gages ranging from .030" to .875". United Precision Products Co., 3525 W. Belmont Ave., Chicago, Ill.

K-58 **Flea Power Motors.** Form 82439, 8½" × 11", 4 pages, lists a.c. induction shaded pole type motors, direct current and universal motors. Speedway Manufacturing Co., 1834 S. 52 St., Cicero, Ill.

K-59 **Tool Chests.** Folder, 8½" × 11", 4 pages, illustrates several tool chests with drawers and compartments of various dimensions to suit machinists' tools and keep them separated according to type and size. George Scherr Co., Inc., 128 Lafayette St., New York, N. Y.

K-60 **Ohmite News.** The December 1942 issue lists the important features of Ohmite rheostats. Ohmite Manufacturing Co., 4835 Flournoy St., Chicago, Ill.

K-61 **Thermometer Data.** Bulletin G23-2, 8½" × 11", 12 pages, discusses the operating principle of Wheelco thermometers, and gives information to aid the user in selecting the proper instrument for his application. A table gives complete details on the characteristics, performance and limitations of each class of vapor-pressure and gas-filled instruments. Similar information to aid in selection of bulb and socket materials, and of capillary and its armor, is also included. Available scales for indicating instruments, and charts for recording instruments are illustrated. Wheelco Instruments Co., Harrison & Peoria Sts., Chicago, Ill.

K-62 **Volt-Ohmmeter.** Leaflet, 8½" × 11", 1 page, illustrates the Model 360 designed expressly for use in the maintenance of military communication services. Triumph Mfg. Co., 913 W. Van Buren St., Chicago, Ill.

K-63 **General Radio Experimenter.** The December 1942 issue is devoted to "Voltage Regulation of Variacs". General Radio Co., 30 State St., Cambridge A, Mass.

K-64 **Hardness Testing.** Leaflet, 8½" × 11", 1 page, gives specifications of hardness tester calibrated: for diamond penetrator using loads of 60, 100 and 150 kg.; for 1/16" ball using the same loads and for a ⅛" ball using 100 kg. Steeltest Instrument & Mfg. Co., 14212 Fenkell Ave., Detroit, Mich.

K-65 **X-Ray Crystal Analysis Apparatus.** Form 58A, 8½" × 11", 8 pages, describes x-ray apparatus specifically designed as a complete, practical working tool for the manufacturer. Philips Metalix Corp., 419 Fourth Ave., New York, N. Y.

K-66 **Wheelco Comments.** The November-December 1942 issue of this house organ gives an explanation of thermocouple construction and assembly, designed to aid pyrometric instrument users in selection of proper types. Discussed and illustrated are thermocouple insulators, connector blocks, heads, protecting tubes, bushings and flanges, lead wire, and lead-wire connectors. Wheelco Instruments Co., Harrison & Peoria Sts., Chicago, Ill.

K-67 **Electric Control.** Catalog N-00A, 8" × 10½", 29 pages. Anyone who is faced with an automatic control problem—whether the controlled condition is temperature, pH, conductivity or percent SO_2—will be interested in this publication. It describes control equipment capable of handling any process which can be controlled by positioning a valve or other regulating device—a control which holds smoothly, surely at the control point, under either transient or sustained changes in demand. Diagrams and text explain in detail how the equipment is adjusted to fit the needs of a particular process. And a number of pictures show the equipment in actual use in a wide variety of applications. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia, Pa.

K-68 **Center Scope.** Bulletin 301, 8½" × 11", 16 pages, describes this device which is an optical centering and locating tool that can be easily and quickly used on any machine to center work reference lines to a spindle axis. Center Scope Instrument Co., 351 S. La Brea Ave., Los Angeles, Calif.

K-69 **Moisture Content of Wood.** Leaflet, 8½" × 11", 2 pages, describes a device, for measuring the moisture content of wood, which does not use contacts penetrating the wood surface. Therefore the device leaves no mark. Hart Moisture Gauges, Inc., 126 Liberty St., New York.

K-70 **Enclosed Ballast for Fluorescent Lighting of Aircraft - Instrument Panels.** Leaflet GEA-3908, 8" × 10", 2 pages lists features of catalogue No. 68G501, 26 volts, 400 cycles. General Electric Co., Schenectady, N. Y.

K-71 **Low and High Temperature Test Chambers.** Leaflet, 8½" × 11", 2 pages describes the Model RTC1 unit which uses mechanical refrigeration. American Coils, Inc., 25 Lexington Ave., Newark, N. J.

K-71 **Circuit Controls for Aircraft.** Folder, 8½" × 11", 4 pages describes a contactor for remote control of starting motors. Guardian Electric, 1615 W. Walnut St., Chicago, Ill.

K-72 **Control Thermometer.** Bulletin G503-2, 8½" × 11", discusses the "electronic principle" of effecting control without mechanical contact between measuring and control sections of the instruments. Also described are program and proportioning thermometers, available in both recording and indicating types, and combinations of thermometers with the Flame-otrol, a combustion safeguard instrument. Schematic drawings are included. Wheelco Instruments Co., Harrison & Peoria Sts., Chicago, Ill.

K-73 **Catalysis Supersedes Slow Combustion.** Bulletin 42-12, 8" × 10", 6 pages describes and illustrates the new Burrell Gas Analysis Apparatus in which catalysis supersedes combustion in the determination of combustible gases. Burrell Technical Supply Co., 1936 Fifth Ave., Pittsburgh, Pa.

Cut and Mail this Card

Instruments Publishing Co., Pittsburgh (Jan. 1943)

Please have the following catalogues, etc., reviewed in this issue sent to me.

Numbers .....

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I also desire further information concerning the following new products described in this month's "New Instruments" Department .....

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